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THE MOUNTAINS OF NORTHERN LABRADOR: *A paper read at the Evening Meeting of the Society on 7 November 1932, by*

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"THE Labrador Peninsula is less known than the interior of Africa or the wastes of Siberia. Its rivers are still stocked with salmon; its inland waters are the breeding places of countless birds. Its numerous and deep fjords, and the splendid mountain scenery of the northern coast, with its Arctic ice-fields and thousand bergs, and the Eskimos, christianized and heathen, will never cease to tempt to this threshold of the Arctic regions the hardy explorer or the adventurous yachtsman." Such were the terms with which A. S. Packard introduced his excellent book, 'The Labrador Coast,' forty-one years ago. And although the interior of what may perhaps be called Greater Labrador is now somewhat better known, though still undescribed and unrecorded, yet the extreme northern peninsula with its wild mountain ranges and complicated and uncharted coast-line has remained practically a closed book.

In a paper to the Society in 1911,[1] Sir Wilfred Grenfell described in general terms the main characteristics of the coast, and mentioned the existence in the north of three distinct mountain ranges: the Torngats, the Kaumajets, and the Kiglapeits. He rightly considered, though from little intimate acquaintance with them, that the Torngat Mountains afforded the highest and wildest scenery along the whole coast of eastern North America, though his statement, based upon the opinion of Dr. Robert Bell and others, that their summits were never submerged beneath the ice-cap of the Glacial Period can now be shown to be incorrect. The Kaumajet and the Kiglapeit groups, lying in the coastal region farther south, are also of an extremely wild and rugged character, but they occupy respectively but a parcel of ground compared with the extensive ranges of the Torngats.

The dangerous uncharted waters of the region and the existence, often until late in the season, of pack-ice and bergs borne southward on the Labrador Current, have been the cause of the long neglect of Northern Labrador. The wreck of the new vessel of the Hudson's Bay Company, *Bay Rupert*, in 1926,

[1] W. T. Grenfell, *Geogr. J.*, vol. 37, 1911, p. 407.

involving an estimated loss of £1,000,000, only brought home once again the dangers of this coast, and emphasized the need of a hydrographical survey. It is of interest that on behalf of the Canadian Government in connection with its development of the Hudson's Straits grain route, the Admiralty have at last been able to commence such a survey this summer (1932), and news has been received that the survey-ship herself, H.M.S. *Challenger*, has not escaped considerable damage from striking a submerged reef.

Numerous navigators, standing wisely out to sea, have without doubt sighted from afar the jagged peaks of the Torngats, though many of them will have obtained but fleeting glimpses owing to the prevalent conditions of fog and bad weather. The probable earliest visitors to the coast were the Norsemen, but the landfall of Thorfinn Karlsefni (or Thordarsson),[1] if it were Labrador at all, in A.D. 1003, at Helluland (=flat-stone land) has not been identified, though some have supposed it to be near Hopedale, or Nain: the mention in the saga of ice-mountains however suggests a more northern locality coincident with the highest portions of the country, or even Southern Baffin Land. Whether the Cabots or Martin Frobisher knew anything of north-eastern Labrador is open to grave doubt, though the latter on his voyages into Hudson Strait, and Corte-Real on his second voyage, most likely sighted the northern peaks. In the latter part of the eighteenth century the Moravian Brethren first gained a permanent footing on the coast, and in 1814 two of their number made a remarkable journey from Okak to Killinek, in the extreme north of the peninsula.[2] On their journey they report interesting finds of slate, jasper, ironstone, and soapstone, and mention grey rocks streaked almost perpendicularly with veins of black stone, which carefully recorded observations are sufficient to indicate the approximate route taken. Captain Manby, R.N., in 1808, approximately charted Port Manvers, north of Nain; and the U.S. Coast Survey Report of 1860 gives a rough survey of Eclipse Harbour, Aulazevik Island, made by Lieut.-Comdr. A. Murray, U.S.N., during a Solar Eclipse Expedition to the Torngat region. The earliest general map of the northern part of the peninsula seems to have been that of another Moravian brother, the Rev. S. Weiz, published some time prior to 1869.[3] On this map the coast-line is represented with but approximate approach to accuracy, while the Torngat Mountains are given a position and extent wholly unlike that in nature. Dr. R. Koch wintered in Nain in 1882 to 1883, and he has written a short account of those parts of the coastal mountains which he saw.[4] Near Ramah he ascended a mountain 2000 feet high, and he considered that opposite the island of Aulazevik the Torngats reached elevations of from 8000 to 9000 feet. He also observed that while mountains less than 1500 or 2000 feet in height are rounded, and bear evidence of having been covered by glaciers, the ragged forms of the higher peaks show no such signs. From the evidence of raised beaches he reasoned that there had been a post-glacial depression of the

[1] Or was it Leif Eriksson? See E. F. Gray, 'Leif Eriksson, Discoverer of America, A.D. 1003,' 1930, for an exhaustive analysis and reconstruction of the question.

[2] Kohlmeister and Knoch, 'Journal of a Voyage from Okkah on the Coast of Labrador to Ungava Bay,' London, 1814.

[3] Referred to by A. S. Packard, 'The Labrador Coast,' p. 226.

[4] R. Koch, *Deutsche Geographische Blätter*, Band VII, Heft 2, 1884, pp. 151–163.

land followed by a slow upheaval. In 1884, on his way to Hudson Bay on behalf of the Canadian Geological Survey, Dr. Robert Bell made a brief visit to Nachvak Fjord, and records the occurrence of Laurentian gneisses and probable Huronian slates and quartzites; and he too considered that the mountains show no evidence of glaciation except in their lower parts.[1] Packard's book, already cited, makes constant reference to the geology, but more particularly of the southern parts of the coast; while W. G. Gosling, in his 'Labrador: its Discoverers, Exploration, and Development,' makes scant reference of any kind to the north.

But it is to Professor R. A. Daly and others of the Brown-Harvard Expedition of 1900 that we owe the first important geological and other detailed work in any part of the extreme north.[2] He made many observations on the solid geology, and paid special attention to glacial phenomena and raised beaches, as well as correcting the existing map and taking soundings of Nachvak Fjord. In 1915 and 1916, Professor A. P. Coleman, on behalf of the Geological Survey of Canada, extended Daly's observations in the Nachvak district and also mapped a section of the mountain region lying inland of Seven Islands Bay to the northward.[3]

Approximate sketch-maps of the inner portion of Ryan's Bay and of Ikordlearsuk [Ekortiarsuk] were made by the Columbus Iselin Oceanographical Expedition of 1926, and Sir Wilfred Grenfell during his several cruises to the north has not failed to avail himself of the opportunities to chart approximately various portions of the north-eastern coast. Of the 700 miles of coast-line from the Straits of Belle Isle to Cape Chidley in the extreme north, it can be said that only the southern one-third as far as Indian Harbour is provided with approximate charts, while the remaining two-thirds, characterized by innumerable islands, reefs, tortuous channels—locally known as "tickles," and fjords—has not been surveyed.

The Grenfell-Forbes Northern Labrador Survey Expedition, 1931

It was at the original suggestion of Sir Wilfred Grenfell that Professor Alexander Forbes, of Harvard, undertook in 1931 to combine a yachting cruise to the northern section of the peninsula with that of a surveying expedition. It was felt that apart from the attractions of a very partially known and rugged mountain region, with ample scope for geological, botanical, and other researches, a really useful contribution to geography might be made if something of a general and hydrographical survey could be carried out within the scope of a single summer season. For it was well known how short the summer season can be in these parts, and that often pack- and berg-ice block large stretches of the coast until late in July or even August. The only possibility of accomplishing much in the limited time available was to adopt some form of aerial survey, and with this in view, and as a useful means of reconnaissance, and, in emergency, transportation into the interior, Dr. Forbes decided

[1] Robert Bell, *Geol. Surv. Can.*, 1882–84, pp. DD 11–17.

[2] Reginald A. Daly, "The Geology of the North-East Coast of Labrador," *Bull. Mus. Comp. Zool., Harvard*, vol. xxxviii, Geol. Ser., vol. 5, no. 5, 1902.

[3] A. P. Coleman, "Northeastern Part of Labrador and New Quebec," *Geol. Surv. Can.*, Memoir 124, 1921.

that two seaplanes should accompany the expedition. That for aerial photography was a Fairchild monoplane fitted with a Fairchild surveying camera, and the smaller machine, the property of Dr. Forbes, was a Waco biplane. As to methods of survey, it was realized that that by means of a vertical

Northern Labrador, from surveys by the Grenfell–Forbes Expedition 1931

mosaic must be ruled out as consuming too much flying time and film. The alternative procedure of oblique photography had been extensively used in Canada and elsewhere where the relief of the country was only moderate, but it had not been applied systematically to a mountainous country. Such a method, giving a contoured map of relatively large area and low expenditure of flying time, seemed ideal for our purpose; and Mr. O. M. Miller, of the

American Geographical Society, who had developed a method, which he designated "plane-tabling from the air," accompanied the expedition as chief surveyor.[1]

Apart from an aerial section of four members, the personnel of the expedition numbered sixteen, several of whom hailed from Harvard University, including Mr. E. C. Abbe, who came as botanist, while the writer, as geologist, and his wife were invited over from England.

The expeditionary ship, the *Ramah*, was a Nova Scotian schooner, 97 feet long over all, originally built for Dr. Iselin, now of Woods Hole, for oceanographical work. Professor Forbes had spared no trouble and expense in refitting and equipping her, and the result was as fine a craft as ever sailed "down the Labrador." A compact and special Murray and Tregurtha 110-horse-power engine designed to run on a safer fuel oil than gasoline, was installed, giving the *Ramah* a maximum speed of 6 knots. But owing to difficulties of fuel distribution on the coast it was on her sails that the *Ramah* had very largely to depend. Through Sir Wilfred's interest the enterprise became known as "The Grenfell-Forbes Northern Labrador Expedition."

Professor Forbes has already elsewhere given an excellent itinerary and categorical description of the chief doings of the expedition, and it is my purpose here to avoid repetition as much as possible.[2]

The *Ramah* sailed from Boston on June 16. Calling at St. Anthony, the Grenfell headquarters in Northern Newfoundland, to pick up the last arrivals on July 2, and thence touching at Battle Harbour, Hawke Harbour, and Gready Island *en route*, we arrived at Indian Harbour, Hamilton Inlet, on July 6. Here we had a most hospitable reception from the staff of the dispensary, the northernmost of that chain of Grenfell establishments, which have done, and are doing, such excellent work for the fisher folk on the southern portions of the Labrador. Indian Harbour was a prearranged rendezvous for the aerial section, whose usefulness became at once apparent from a reconnaissance flight of 80 miles up the coast to observe the conditions of pack-ice prior to our setting sail. Moreover Dr. Forbes was able to assure himself of a course for the *Ramah* which was more or less clear of shoals and hidden reefs for the next part of our passage. But we were not free of local difficulties even in Indian Harbour, for the local chart showing $2\frac{3}{4}$ fathoms proved to have only 8 feet at low tide, and our draught being 11 feet, we fetched up on an unexpected ledge. Sustaining no perceptible damage and floating off next day, we put in for the night at Aillik Harbour, and on the 11th sailed into Hopedale, through a labyrinth of islands and sounds. Hopedale is still one of the chief stations of the Moravian Mission to the Eskimos, of which there are now five centres on the northern half of the coast. From the Rev. W. W. Perrett, the kindly superintendent of the Mission, we were able to obtain much information of an important character regarding Eskimo place-names and their meaning. One of the most interesting and beautiful portions of our voyage now followed,

[1] O. M. Miller, "Plane-tabling from the Air: an Approximate Method of Plotting from Oblique Aerial Photographs," *Geogr. Review*, vol. 21, 1931, pp. 201–212; and Additional Notes on "Plane-tabling from the Air," *ibid.*, vol. 21, pp. 660–662.

[2] Alexander Forbes, "Surveying in Northern Labrador," *Geogr. Review*, vol. 22, 1932, pp. 30–60.

via Davis Inlet, with its Hudson's Bay Company port and encampment of Nascopi Indians, and beyond, *via* narrow sounds and steep forest-girt hillsides, to Nain, another Moravian station and chief fur centre on the north-east coast. Personally I had long looked forward to seeing something of this section of the country, since for nearly 100 miles up and down the coast there outcrops the interesting and unusual anorthosite formation from which is obtained in certain areas the lustrous precious labradorite. Time did not permit, unfortunately, of my visiting the best-known locality where it has been quarried, at Napoktulagatsuk Island [1] some 12 miles south of Nain, but at the latter place beautiful specimens were presented to members of the party by the Rev. P. Hettasch, of the Mission, and by Mr. Heath, the Hudson's Bay Company factor. Brief examination at two places in the vicinity of Nain enabled one however to gain some idea as to the degree of local differentiation of the anorthosite, and it is gratifying to know that Mr. E. P. Wheeler, of Cornell University, is intending to devote several years to research on this notable formation: he has already published some results of his topographical work in the neighbourhood.[2]

Sailing north *via* the tortuous and fjord-like Port Manvers "run," we gained the open sea in full sight of the Kiglapeit Mountains, which signify sierra, or dog-tooth mountains. These, the southernmost of the three ranges of Northern Labrador, are a great northern rampart of the anorthosites, and though estimates have varied widely in the past, their altitude has been shown by Wheeler not to exceed 3000 feet in all probability. Attractive though they looked we were bound to pass by, and on a memorable evening (July 16) we sailed into the southern end of Mugford Tickle, and found anchorage in a beautiful cove beneath the towering forms of the Kaumajet Mountains.

The Kaumajet Mountains

In this range, whose name implies, in Eskimo, the "shining mountains," we had planned, not to commence the main survey work, but to make a few geological and botanical observations, which might throw light on certain conditions likely to be encountered in the Torngat Mountains farther north.

The Kaumajets do not cover in all probability a greater area than 150 square miles, but what they lack in extent they make up for in form and the amazing abruptness with which they confront the Atlantic. Cliffs of 1000 feet or more are not infrequent at Cape Mugford and within the cañon-like "tickle" which runs between the island of Ogua'lik and the great scarps of the mainland.

R. A. Daly (p. 219), during his brief visit in 1900, showed the existence here of an irregular rock-basement of contorted and faulted gneisses and amphibolites, on which were resting a sedimentary and volcanic series. But time had not permitted of his ascertaining the thickness or extent of the various formations, nor was he able to reach any of the summits of the range. In company therefore with Abbe and Kennard, I spent a profitable day in making the

[1] The text-books wrongly state that the precious mineral is procured from Paul Island, or Pownal Island, as it should be more correctly called. Napoktulagatsuk Island is often referred to as Taber Island, after its first owner.

[2] E. P. Wheeler 2nd, *Geogr. Review*, vol. 20, 1930, pp. 454–468.

Bishop's Mitre from the north-east; Brave Mountain on right

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Mount Blow-me-down; Bear Gut on the left

ascent of two of the southern points of 2775 and 2900 feet by aneroid respectively, which rose from a rock-strewn mountain upland at about 2000 feet. The upland was only reached from a remarkable cauldron-like valley, tentatively called the "Valley of the Twin Falls," by a fortuitous break in the continuous cliffs, which on the east side formed a gully, yielding a 700-foot climb of some difficulty. The massive volcanic rocks, lying more or less horizontal and composed of dark basaltic lavas and ashes, were traversed to the highest point reached, and since the older basement series of gneisses and ashes, on which the volcanics were seen at many points to be resting, did not extend more than 500 feet above sea-level, one had a measure of the great thickness of the volcanic series. At several places however a thin sedimentary series of slates was seen to form the lowest part of the volcanics, and the presence of such a series, which included quartzites and limestones, as well as slates, was found by Daly to be present on Ogua'lik Island to the eastward.

But what to the botanist and geologist of the party was a matter of particular interest was the presence on the high upland at 2000 feet of much material of plainly erratic character. This upland, which extended over much of the southern part of the range, was deeply weathered, the rough and scoriaceous lava being readily disintegrable by frost action. Scattered at intervals upon the darker lavas were blocks of granite and amphibolite, such as are common to the older Basement rocks of the country, which with the evidence in places of planed and polished rock surface was a clear indication that to this altitude at least the range was once overridden by the Labradorean Ice Sheet. Plants were almost completely absent, the only one of note being the little yellow composite *Crepis nana*, which here and elsewhere in a few localities of Arctic Canada has been considered by Professor M. L. Fernald a "conservative" and Cordilleran relict species, established prior to the last glaciation.[1] The difficulty of reconciling such a thesis, either in the Kaumajet Mountains or, as will be seen later, in the Torngats, with the evidence of recent glaciation will be at once apparent.

Our passage later northwards through Mugford Tickle gave evidence of considerable departure from horizontality of the massive beds of volcanics of which this profound and beautiful strait is composed, their junction with the underlying crystallines dipping below sea-level at more than one place.

It was not till our return from the north some five weeks later that another day could be devoted to this most interesting district. From an anchorage in the tickle, Abbe, Morris, and the writer covered the 8 or 9 miles separating us from northern peaks of the range in a "speed-boat"—tender to the *Ramah*. Our object was "The Bishop's Mitre," one of the most striking mountain forms on the whole coast of Labrador, the neighbourhood of which seemed to offer possibilities of further geological and glaciological evidence, as well as an opportunity of an interesting first ascent. A landing was made at the foot of the long shoulder and spur which descended in an easterly and south-easterly direction. Having crossed the upper junction of the Basement crystallines at about 200 feet above sea-level, our way lay over steep rough scree slopes of volcanic materials to a point about 3060 feet (by aneroid). On the broadened

[1] M. L. Fernald, "Persistence of Plants in the Unglaciated Areas of Boreal America," Memoirs of the Gray Herbarium of Harvard University II, 1925, pp. 252, 316.

Mount Blow-me-down; Bear Cut on the left

and but slightly sloping crest of the shoulder at this altitude we noticed stone-polygons (*Rutmarken*) in the hard volcanic ash, and in furtherance of our researches upon this interesting freeze-thaw phenomenon in Spitsbergen [1] and elsewhere, we made a hasty excavation to a depth of about 2 feet. Although some of the polygons, which had a maximum diameter of 5 feet and were never continuous, appeared to be well differentiated, the one investigated was less so. It had blocks of the prevailing ash irregularly disposed in the centre as well as at the periphery, and the finer soil, though drier towards the surface, was in depth wetter and more finely comminuted. No ground-ice (*tjaele*) was found, as might have been the case earlier in the season, or possibly with deeper excavation, but the occurrence seemed to confirm one's earlier findings that every frost-polygon must have a foundation of comminuted mud, which by repeated frost expansion brings about the soil differentiation, although certain features of the whole process are as yet obscure.[2]

Beyond the top of the shoulder was a long and remarkably flat causeway which led to the foot of the final peak of the mountain. A careful examination of this flat slabby ridge eliminated the first impression that it might be attributable to the horizontal joint planes of the rock, and I could only conclude, from the rather indefinite evidence of weathered polish on some rock surfaces, that regional ice-action had been operative here at 3000 feet: the configuration of the place quite forbade local mountain ice-action. The final crag to the top of the east peak of the Bishop's Mitre presented no difficulties, our aneroid reading 3750 feet, which compares unfavourably with the estimated 3000 feet on the chart. The earlier clouds had cleared and we had a remarkable view from this isolated summit of a sunlit almost Mediterranean-like sea, though the barren rocky coastal precipices and the scattered "growlers" struck a somewhat different note. Perhaps 3 miles to westward rose Brave Mountain, named after their ship by the Brown-Harvard Expedition of 1900, and it was at once apparent that this summit must be not less than 500 feet higher than the Bishop's Mitre, possibly 4200 to 4400 feet, and the highest peak in the Kaumajets. On its eastern flank lay an extensive *névé* at an estimated mean altitude of 2500 feet, and this is in all probability the southernmost perennial ice-mass in Labrador, and indeed in Eastern America. Nearer at hand and across a profound gap was the western peak of the Mitre. The descent into the gap was made over steep though not particularly difficult rocks, and this remarkable feature was found to be rather more than 300 feet deep. Since there has been much conjecture on the part of voyagers to this coast as to the true nature of the gap, some having supposed it to be a fault feature,[3] it was of some interest to find that it is due to the weathering out of a basic dyke rock cutting the volcanic series, which here largely consisted of spherulitic lava and breccia. The view from the gap down a continuous 3000-foot icy couloir to the sea was as impressive a sight as the writer can recall. A first-rate rock climb from the gap gave out on the western peak of the Mitre, which at 3700 feet was

[1] J. S. Huxley and N. E. Odell, "Notes on Surface-markings in Spitsbergen," *Geogr. J.*, vol. 63, p. 207.

[2] See also C. G. Elton, "The Nature and Origin of Soil-polygons in Spitsbergen," *Quart. Journ. Geol. Soc.*, vol. 83, p. 163.

[3] J. W. Gregory, 'The Nature and Origin of Fiords,' p. 286.

found to be but slightly lower than the eastern peak. Cairns were erected on both east and west peaks.

Wishing to extend my observations to the western summits of the range, I sent my companions back from the col at 2750 feet west of the Mitre, and making all haste continued over a long pinnacled ridge to a summit lying south-south-west of the Mitre and south-south-east of Brave Mountain. This point at 3620 feet commanded a fine view to the south-westward, which was limited by a distant range of peaks and rounded summits, lying possibly in the neighbourhood of the George River, and which by Abney level and allowing for the Earth's curvature seemed likely to be over 4000 feet in altitude. It could also be seen that the Kaumajet Range was terminated on the west by as abrupt scarps as on the east, low undulating country extending to the distant range, perhaps 60 to 70 miles away.

The weathering on Point 3620 feet was sufficiently deep for well differentiated frost polygons, up to 3 feet diameter, to have developed on the rounded summit. Yet on the south-east slopes and within 30 feet of the summit bare coarse lava surfaces showed ice planation, though with some partial decay. If this planation were due to the last glaciation (Wisconsin), as seems likely, it is the highest evidence yet found in the Kaumajet region and amongst the highest in Northern Labrador. No unequivocal erratic material could be found.

From this somewhat distant point, and back over the shoulder of the Bishop's Mitre, it took me two hours' hard going to reach the coast at our morning's landing-place at dusk. We had no sooner embarked in the small speed-boat than a fresh breeze got up, showering us with spray and repeatedly stopping the engine. Intensely phosphorescent waves broke over us, drenching us with icy Arctic water, while all our energies were fully devoted to baling and paddling the boat into the teeth of the squall owing to the failure of the engine. Brilliant northern lights played overhead and a vivid branching meteor at one moment startled us from the work in hand. The dark setting of the beetling ghostly cliffs around us added impressiveness to the scene, and we were not an unthankful party which shortly after 11 p.m. were welcomed on board the *Ramah* in Mugford Tickle.

From Hebron, another Moravian and Hudson's Bay Company centre, situated on the coast about 40 miles north of Cape Mugford, I was able during a most illuminating flight in the Fairchild plane to confirm my earlier impression that the Kaumajet Mountains form an isolated and restricted coastal group both topographically and geologically. In brief they are a great assemblage of mainly volcanic materials not less than 4000 feet thick, but the vent or vents from which all this great mass was ejected is, or are, unknown: such may have been eroded down long since to the very roots below the level of the sea. The age of these rocks is in doubt, since the few sedimentary rocks associated with them are entirely lacking in fossils. It is however more than probable that they are pre-Cambrian, since they occupy a similar position and relation to the crystalline Basement rocks as the mainly sedimentary Ramah Series farther north: the latter have been considered to be probably Huronian in the Canadian geological succession.

The above flight also proved to be of local hydrographical value since

Hebron Fjord was found to be much longer than shown on existing maps and charts, and moreover five large rivers were found to debouch into it.

The Torngat Mountains

Having passed the wide opening of Saglek Bay at lat. 58° 30′, we were abreast of the southern peaks and summits of the Torngat Mountains, which are abruptly cut off by the bay and its great inner fjords. Torngat is said to signify in the Eskimo tongue "the abode of spirits," but the frequent interpretation of "evil spirits" seems incorrect, since *torngak* (sing.) sometimes means "a nice little assisting spirit," and hence is not necessarily baneful! As seen from the sea these mountains are of the wildest possible aspect, and one can well imagine the primitive mind freely peopling them with spirits of all denominations and reputations. A notable domed and snow-patched summit hereabouts, whose vicinity is somewhat feared by passing fishing-schooner captains, is Mount Blow-me-down, named after its compeer of similar evil reputation in Western Newfoundland—whose name is derived incidentally from the native form "Blomidon." Short-range aerial photographs of the Labradorean summit reveal that the snow-patches are cwm-ice masses occupying deep scallops in an elevated portion of the old erosion-surface out of which this prominent summit and others have been formed. Not the least striking feature of this section of the coast, as recorded by Professor Daly, is the remarkable display of black dyke-rocks traversing in varied and irregular network patterns the lighter gneissic rocks, and adding a further mysteriousness to the scene. In a prominent headland seamed with these dykes and aptly named "The Muzzle," one almost felt relieved that the watch-dog of the Torngat had been thus rendered innocuous! Curious nomenclature abounds hereabouts, for hard by, also, is a fjord-like opening known as Bear Gut.

Thence we entered Nullataktok Bay, of truly Norwegian fjord aspect, and after adventures aground on a delta lying beyond the old Moravian mission station of Ramah, we found ourselves next day in Rowsell Harbour. Here I had an opportunity of visiting the old pyrite working, at the head of the bay, which has been abandoned since 1905 owing to the narrowness of the seam and the short season of open water.[1] The mineral, which was worked for sulphur, occurs in the Ramah Series, named by Daly and hereabouts described by Coleman, and occupies veinlets within the bedding planes of the shales, part of which it has replaced. Rock-movements have sheared the veins and broken them up.

Sailing from Rowsell Harbour in thick fog on July 21 we rounded Gulch Cape and Cape Whitehandkerchief, seeing nothing at this time of the grand entrance to Nachvak Fjord. It was on this day that the use of reconnaissance aerial photographs, obtained on a previous flight from Hebron by our plane, as well as the navigating skill of Dr. Forbes, were strikingly demonstrated. The faultiness of the chart hereabouts is extreme; but by a process of feeling our way round and—according to the chart—through headlands, islands, and shoals, and by recognition of shore features on the photographs, we found ourselves that evening, in utter amazement at the pilotage of our leader, at our proposed base in Kangalaksiorvik Fjord. As later determined the place

[1] W. T. Grenfell, *op. cit.*, p. 414.

Mugford Tickle: cliffs of Ogua'lik Island

Mount Blow-me-down, showing cliffs seamed by black dyke-rocks

Cape Whitehandkerchief from the summit of Mount Razorback

Four Peaks Group from the north-east; entrance to Ryan's Bay on the right

was situated at lat. 59° 22′ 31″ and long. 63° 47′ 02″, and it had been selected by Miller four days previously during a reconnaissance flight from Hebron. Kangalaksiorvik, which curiously means "the place where they hunt reindeer when their hair is shed," is a large fjord running in from the opening marked on the charts as Seven Islands Bay. It had been visited by Professor Coleman during his examination for the Canadian Government in 1915, and following the incorrect nomenclature of the Admiralty Chart, he has termed this fjord Komaktorvik (Coleman, *op. cit.*, p. 30). The latter however is a neighbouring smaller opening running south-west from nearer the entrance to Seven Islands Bay: it is also indicated on the chart as Louse Bay, which indeed is the meaning of Komaktorvik, though perhaps more precisely "sea-lice." The actual anchorage, which became known to us as Seaplane Cove, was on the south side of Kangalaksiorvik Fjord, with Mount Tetragona, named and mapped by Professor Coleman, lying just to the westward. In full view northward was the group of the so-called "Four Peaks," about whose altitude so much discussion and exaggeration have arisen in the past. Seen from off-shore near Ryan's Bay to the north-west, four peaks may seem to dominate the view, and they may appear under certain conditions to rear their heads 8000 or more feet, but from the present aspect the group could be seen to comprise at least fourteen peaks, and an altitude of 4500 feet seemed a nearer estimate for the highest of them. On our east, enclosing the cove, was a prominent headland which later we ascertained from some Eskimos in Ryan's Bay to be called Naksungatalik,[1] which means "bridge of the nose," and is very plausibly descriptive of that feature.

Seaplane Cove was to be the base for activities of all kinds during the next three weeks. On the flat neck of land to our southward Miller's party were soon at work on the establishment of a base-line, following a reconnaissance in preparation for the local triangulation which was to serve as part of the ground control for the aerial survey. This local network was tied in to an automatic tide gauge, fixed on a rocky point nearby, enabling a sufficiently precise determination of mean sea-level to be made. The tide range, incidentally, was recorded here as never greater than about 4 feet, which is in marked contrast to the 50-foot tides reported from the entrance to Hudson Straits. An interesting relevant phenomenon, and one referred to earlier by Coleman (p. 12), is that the two diurnal tides on this coast are of very unequal magnitude, which amounts at times to 2 feet. This fact, on two occasions when the *Ramah* had run aground at one high tide, enabled her unexpectedly to float off at the next high tide. During a succession of flights from Seaplane Cove as base, the aerial party was able to cover the entire region with photographs taken from altitudes ranging from 4000 to 9000 feet. On one day, August 3, during an exceptional spell of good weather, the Fairchild plane spent seven hours in the air, securing a total of 330 pictures from south of Nachvak Fjord to the Button Islands in the entrance to Hudson Straits, and ranging from 5 miles off-shore on the east to a similar distance on the Ungava Bay side. Such fine days were rather the exception than the rule, for periodically from the north-east would

[1] This actually was the form of the word given us by Mr. Perrett, of Hopedale, whose knowledge of the Eskimo tongue is not to be questioned: spelt phonetically our Eskimo informants' word seemed more like Nehungateluk.

Four Peaks Group from the north-east; entrance to Ryan's Bay on the right

bear down on us such biting moisture-laden gales that our activities were completely checked: we noticed that these gales frequently took three days to blow themselves out. But we did not observe here any chinook (or föhn) such as Coleman refers to (p. 11), though later, farther north, at Ikordlearsuk, a corresponding effect was experienced on one occasion.

Local work at Seaplane Cove included the taking by Dr. Forbes of a number of soundings across the entrance to Kangalaksiorvik Fjord, while a vertical photographic mosaic of the corresponding area was taken from the air: this was insufficient however to prove whether this opening conformed to a true fjord or a ria, as Daly's soundings at Nachvak had done regarding that feature.

At all portions of the coast visited a keen look-out had been kept for such indications of old native camps or settlements as might suggest the earlier existence, not merely of the Eskimo, but of the mysterious bygone race called by the latter the Tunnit. The reader is referred to the writings of Mr. G. M. Gathorne Hardy and others [1] on the Tunnit, and it is sufficient here to say that, of the little that is so far known of them, they appear to have had many characteristics foreign to the Eskimos. Unfortunately we were not successful in finding any unequivocal Tunnit remains, though some stone-igloos on the side of Naksungatalik yielded some interesting quartzite implements. These were dug from a depth of 1 foot or more in the floor, and I am informed by my friend Mr. R. J. Eaton, of Boston, Mass., to whom I submitted them, that they have certain characteristics in common with artifacts from Maine, and in gross aspects are identical with those of the Red Paint culture of north-eastern North America. But pending examination by other experts, it is perhaps premature at present to trace such a widespread, though interesting, possible connection between these early cultures, and the existence in this particular locality of either aboriginal Indian or definitely even of Tunnit. That the Tunnit nevertheless, whoever he was, formerly inhabited the north-eastern coast of Labrador, Hudson Strait, and South Baffin Island seems to be borne out both by strong Eskimo tradition as well as scattered archaeological evidence, and it is a problem, as Gathorne Hardy has said, well worthy of further research before the evidence is completely lost.

During a landing at Hopedale I had been much interested in a small stone structure on the west side of the harbour. Being rectangular and of rough, apparently antique masonry as opposed to the predominantly sod construction of Eskimo igloos, it seemed to suggest Tunnit origin. I was somewhat disappointed later, and perhaps not altogether convinced, to be told by Mr. Perrett, of the Moravian Mission, that the structure, as far as he knew, was merely a hunting "blind" for duck shooting—such are the pitfalls and disappointments for the would-be archaeologist, even in Labrador!

During our wanderings in the North we came across but few relics of either earlier or later human occupation, occasional stone tent-circles and graves of

[1] G. M. Gathorne Hardy, "A Recent Journey to Northern Labrador," *Geogr. J.*, vol. 59, 1922, pp. 153–167; *ibid.*, vol. 67, 1926, pp. 140–141. E. W. Hawkes, "The Labrador Eskimo," Memoir 91 (No. 14, Anthropological Series), pp. 143–150, Geological Survey, Ottawa, 1916. W. D. Strong, "Stone Culture from Northern Labrador," *Am. Anthrop.*, 1930, N.S. 32, pp. 126–144.

the Eskimo being almost the only objects found. Indeed these were almost as infrequent as the remains of any animal life, such as the caribou, whose herds, if they ever roamed the mountain valleys of the Torngat country, have now forsaken them. And as to present-day Eskimo, but one encampment, at Ryan's Bay, was seen between Hebron and Killinek, so fast has been the decline in recent years of the native population. This decline has been largely due to the terrible influenza epidemic of 1918, which almost wiped out some populous settlements. It seems probable that the total Eskimo population of this part of Labrador numbers to-day considerably less than one thousand persons.

The earlier work of Coleman in the neighbourhood of Kangalaksiorvik had been confined mainly to the inner borders of the fjord and the group of Mount Tetragona on its southern side. He carried out a compass survey, and recorded the presence of metamorphic rocks of Grenville (pre-Cambrian) type, and of former greater glaciation. It is of interest that Coleman was quite unaware that the vicinity had been visited and his Mount Tetragona [1] already ascended in 1908 by E. S. Bryant and H. S. Forbes (cousin of our leader), who had called it Mount Komaktorvik. The latter party had moreover examined and photographed in detail the terminal front of a glacier on the northern side of the mountain, and it was a matter of some importance that we should revisit this locality to ascertain what modification might have taken place in the interval of twenty-three years. A trip to the inner recesses of this wild mountain group, with Brewster Morris as his companion, revealed to the writer that superficially not a great deal of change had occurred. The valley leading up to the north face of Tetragona had three lines of recessional moraine, the lowest at 1175 feet above sea-level, and distant some 1600 yards from the present ice front, having its boulder material much weathered and colonized by plants and mosses. The uppermost moraine at 1350 feet retained a small blue-green glacial lake on the farther side of which was the moraine-covered terminal ice of "Bryant's Glacier." Armed with copies of Bryant's photographs, it was now easy to recognize that it was from this moraine that he had taken his panorama; and in order to record the more precisely the changes since 1908 we found the position as near as possible occupied by him, and erecting a cairn on a large boulder we took our round of photographs. We could see clearly that the large mound of bare ice prominent in Bryant's photograph had dwindled to a moraine-covered mass almost level with the surrounding glacier. Concealed stagnant ice might be present beneath the moraine right up to the border of the lake, but visible ice had receded about 100 yards from the position of 1908. We thought that we could identify a large block visible in Bryant's photograph just above the left-hand end (facing) of the snout, which had now moved forward towards the lake about 80 or 100 yards, but this was doubtful. The present altitude of the snout is about 1380 to 1400 feet above sea-level. We ascended over this and the "dry" glacier of the lower portion into the *névé* basin beneath the impressive cliffs of the north face, which here spring abruptly to a height of nearly 3000 feet above the ice. It was of interest that in this cirque-cut basin no bergschrund marked the foot of the cliffs. The short main trunk of the glacier was fed by an eastern and a western branch, the full extent of

[1] Coleman, *op.cit.*, p. 31 : named presumably after the Arctic heath, *cassiope tetragona*, which however we were unable to find in the vicinity of the mountain.

these branches to the combined snout being less than three-quarters of a mile.

The water of the lake proximate to the ice front was of the usual cloudiness from suspended matter, but the water issuing from it was only of the slightest turbidity, while that issuing from a lower lakelet, itself cloudy blue-green, was as clear as any non-glacial stream.

From the above facts it would seem that Bryant's Glacier is in a state of active recession and but a stage removed from stagnation. It appears that the front may have retreated 80 to 100 yards in the twenty-three years' interval, equivalent to 10·5 to 13 feet per year. This glacier was found to be very similar both in configuration and condition to others visited in the Torngat Mountains: indeed it is a typical example of many such waning relics hidden in the inner recesses of the range, which approximate closely to the kårsa type of glacier of Swedish Lappland.

An ascent and traverse of Mount Tetragona by Abbe and the writer enabled a clearer idea to be obtained as to the disposition and standing of the group of the "Four Peaks," so called, to the northward across the fjord. A puzzling member of the group, which had been designated peak "B" by Bryant, could now be differentiated from another of remarkably similar outline, which on a later occasion was climbed in cloud by Dr. Forbes and the writer on the assumption that it was "B": the latter, as a result of Miller's triangulation, has turned out to be the highest point of the group at 4415 feet, and the group must hence be deprived of the romantic credit of so much greater superiority heretofore attributed to it! Curiously enough Mount Tetragona has been computed to be of exactly equivalent altitude, compared with Coleman's figure of 4700 feet.

It had been planned that I should have the facility of one of the planes for a good deal of geological exploration in the interior. Owing to the number of lakes available on which to alight, one could in this way have covered wide areas on foot from these lakes as bases. But this general plan was impossible of fulfilment owing to shortage of petrol, consequent on a failure of shipping facilities up the coast from the south. I had the advantage however of one such camp, in the vicinity of which an important extension of one's coastal observations could be made.

From Seaplane Cove, in brilliant weather, Dr. Forbes flew me in his own Waco machine to the head of Kangalaksiorvik Fjord and on inland to the Central Range, which occupies a position westward of the coastal groups of Mount Tetragona, the "Four Peaks," and Mount Razorback. We turned southward to the head of Nachvak Fjord, and following its entire length to the sea, returned over Razorback and the coast-line. This gave us an astonishing view of the greater part of the Torngat Mountains, and moreover enabled me to select a suitable locality for a base for geological work in the interior. The spot chosen was about 20 miles inland, by a wild fjord-like lake which cut athwart the folds of the Central Range. Most of the equipment and three of the party were flown in, while Abbe and I had a long and interesting trek in on foot. We traversed Mount Tetragona from east to west *en route*, and learnt during a short benightment that the mosquitoes of Labrador can bite even with the temperature as low as 39° F., an accomplishment usually denied

Four Peaks Group from the north; Mount Tetragona (flat-topped) in the centre background

Looking west over Komaktorvik Lake; Tower Peak on the right

them! At the camp we were eventually given a more than adequate demonstration of what this end product of pestilential evolution can perform at all hours of the day or night, and whatever the temperature!

Half a mile or so below our camp was a little rocky ravine with a beautiful limpid cascade descending from the outlet of the Komaktorvik Lake, so named by us from the fjord into which it eventually drains. From the cascade excellent salmon could be procured for our camp "table," and there were signs that Eskimo are wont to visit the place, for a rough masonry lean-to hut was present nearby, as well as a typical Eskimo grave of open stone-work. In contrast to the scanty flora of the exposed coastal region, it was not altogether a surprise to find in the sheltered tracts of the Komaktorvik valley dense growths of dwarf birch, willow, and alder, as well as an increase in arctic and alpine flowering species. This increased luxuriance of the vegetation Coleman has attributed to the probable effect of chinook (föhn) winds from the west. This however seems of doubtful potentiality during such a season as 1931, when the icy north-easters prevailed, and only one day with anything like a chinook wind was experienced farther north at Tessiujarsuk.

In five days, and in spite of wet and misty weather during two of them, we covered a considerable portion of the vicinity and made the ascent of two notable peaks: "Tower Peak," about 4000 feet, and another of the Central Range south-west of the camp computed by Miller to be 4697 feet, and one of the highest of the Torngats so far determined. Neither proved to be more than a rough scramble, although the latter in particular entailed long traverses of the typical boulder-fields (Daly's "Felsenmeer") so prevalent in Labrador. These extensive and exasperating fields of boulders, which cover at times square miles of mountain slope and valley, are not so much the result of deposition by the earlier glaciers as the subsequent work of frost-splitting and graded movement ("solifluction") in a region where temperature fluctuates much on either side of the freezing-point, and absolute humidity is prevailingly high. Such has been the effect of these conditions that features which were overridden by the last continental ice-sheet of perhaps twenty-five thousand years ago are now covered in many cases with frost-riven material. True it is that a great deal of the material of the boulder fields has been split from crags by lateral erosion and distributed by creep or other agency, but it is on upland areas also and on the broad rounded summits of the Central Range that loose disintegrated material is often to be found to a depth of several inches or even a foot or more. This latter condition of "nivation" Coleman in particular has taken as a criterion that the ice of the Glacial Period, or at least its final sub-epoch the Wisconsin, did not cover the higher summits, but that they projected above the local glaciers whose general level was not higher than about 2000 feet above the sea.[1] Indeed he is gravely sceptical of ice-action by even the earlier Pleistocene sub-epochs, and points to the jagged peaks of the coastal ranges, as Koch and Bell had done, as evidence of the existence of nunataks probably throughout the whole of that epoch. I was able however to find relics of ice-polished surfaces on the upper parts of mountains in various districts, and here in the Central Range also close to the summit of one of the highest peaks,

[1] Coleman, *op. cit.*, p. 26; and "Extent of Wisconsin Glaciation," *Amer. Journ. Sci.*, xx, 181, 1930.

Looking west over Komaktorvik Lake; Tower Peak on the right

at approximately 4700 feet. Some of these polished surfaces were partially corroded, and erratic blocks where present were often superficially weathered; but this, in the nature of things, cannot be considered surprising. It has been argued that such weathering and corrosion indicate that these peaks have not been ice covered, or at any rate that they must have emerged above the local ice-fields of the most recent (the Wisconsin) glaciation. It is the writer's view however that such is a dangerous argument unless due account be taken of the particular climatic conditions obtaining in a region. In Spitsbergen, for instance, where very similar conditions of high humidity and low temperature prevail, one learnt the potentiality of this factor of rapid frost action. There mountain areas of very similar configuration to those of Northern Labrador, which had but relatively recently emerged from the ice, were often covered with a thick layer of frost-riven material; and similarly in the coastal regions of western Spitsbergen are to be found many peaks of jagged aspect, which have longest projected above the waning ice-sheets and endured the optimum of weathering agency. The writer was strongly impressed with the parallel circumstances and conditions of the two countries, Northern Labrador being merely so much farther advanced in the "Cycle of Glacierization."

A similar state of affairs has been shown to exist in the high interior of Norway,[1] and in the White Mountains of New England,[2] where the visible effects of erosion are very variable and a considerable depth of weathering is found on formerly glaciated summits.

Coleman moreover has claimed from his examination of the Nachvak region that the continental ice-sheet from the Labradorean centre of radiation in the interior was never able to gain access to the Atlantic through the valleys of the Torngat Mountains. The present writer however agrees with Daly that there is evidence to the contrary, and that not only are there several examples of long graded "through" valleys cutting transversely across the ranges from the uplands on their western side, but that the accompanying evidence of moutonnée forms together with that of ice-polish on the highest summits of the Central Range, already quoted, can only be attributed to general regional glaciation. Indeed the valley at the head of Nachvak Fjord, extending past Tessersoak Lake, which Coleman visited, appeared from the air to be an exactly similar feature to the great trench to the north on Komaktorvik Lake on which our camp was situated. The latter lake is about 500 feet above sea-level, while the former, according to Coleman, is only 50 feet, and in each case they are fed by a river which rises in the lower country westward of the range. The fact that the "height of land," or watershed of the country, lies considerably to the west of the highest peaks of the Central Range, themselves the westernmost of the Torngats, is of course an important physiographical phenomenon in itself, indicating as it does the inconsequent, and probably antecedent, character of the drainage of the region. But significant otherwise of glacial maturity, these great graded troughs with their clear evidences of ice-action bespeak drainage from some centre of dispersal in the far interior, and cannot be attributed alone, as Coleman would have it, to the

[1] Werner Werenskiold, "The Surface of Central Norway," *Amer. Geogr. Soc.*, Memorial Volume, 1915.

[2] Ernst Antevs, 'Alpine Zone of Mount Washington Range,' Auburn, Maine, 1932.

effects of local mountain glacierization.[1] At the onset and wane of each glacial inundation the Torngats were undoubtedly the gathering grounds of great glaciers that have deepened many of the valleys by which the several ranges are dissected, and there is ample evidence, particularly amongst the rounded summits and broad shoulders of the Central Range, that strong erosion of this character proceeded while the higher features were relatively protected by *névé*. Cirque action has scalloped the eastern flanks of the Central Range as the *névé* covering progressively diminished, but our numerous aerial photographs show that this has been very much more intense, and has proceeded to maturity, in most of the coastal groups, such as the "Four Peaks," Tetragona, and Razorback, since they must have emerged and suffered sub-aerial erosion much longer than the ranges nearer the radiation centre, or centres, of the interior. An exception to this seems to have been Mount Blow-me-down, as earlier instanced, and a few other lower coastwise summits of the southern Torngats, in which dissection by cirque action has not proceeded so far as to destroy the whole of the old erosion-surface. Westward of these coastal groups however are to be seen numerous portions of the same erosion-surface in the level-topped and mostly asymmetrical crests of the interior ranges, indicating apparently all stages from youth to maturity from the standpoint of the usually accepted cycle of mountain glaciation. But it would seem from the evidence above cited that we are dealing here with the superposition of the latter mountain cycle upon an earlier continental glacial one, which gave rise wholly or partially to the erosion surface. Instead of this erosion-surface being prima facie a stream-formed peneplain of the more usual kind, its fluvial character has in all probability been sufficiently modified by overriding continental ice from the interior as to warrant its designation as a glacial peneplain. Evidence is wanting as to whether or not more than one advance of the continental ice took place over the region, but several stages, or levels, of ice-inundation of the interior ranges could be traced. Nor is it safe to attribute to the final stages of the last general inundation all the effects of local glaciation to be seen in the recesses of the mountains. Many of the cwms and cirques may well have been formed, or their moulding initiated, at the commencement of the Wisconsin sub-epoch (or earlier if glaciation has been multiple), and have been later spared complete destruction.[2] But, on the other hand, embryo and youthful cwms are to be found that must be attributed entirely to post-Wisconsin action.

Apart from the enormous talus fans and deltas descending from cliffs and fluvial tributaries, the Komaktorvik River valley was floored with glacial debris of variable origin. In the lower valley was a series of four terraces of gravel and silt, and showing stratification, on the surfaces of which were resting many erratic blocks. In the upper valley in the vicinity of Komaktorvik Lake, apart from an entrenched plain of ground moraine and outwash gravels, there were to be seen glacio-lacustrine deposits with many fine examples of kettle-holes. The present lake—or twin lakes, for such they really

[1] Glacierization (Wright and Priestley, 'Glaciology') is indicative of inundation by ice, as opposed to its effects (=glaciation).

[2] For a parallel case, see J. W. Goldthwaite, "Glaciation in the White Mountains of New Hampshire," *Bull. Geo. Soc. Amer.*, vol. 27, 1916, p. 290.

are—would seem to be a descendant of an earlier one that stood at the end of the extinct "Komaktorvik Glacier" as it retreated or stagnated, and finally vanished in the inner recesses of the Central Range, or on the western flanks of the latter.

Coleman remarks upon the scarcity of boulder clay in the region, and suggests that it may have been deposited off-shore on the submerged continental shelf. In this connection it may be mentioned that on one or two occasions the *Ramah's* anchor brought up true plastic *till* from the fjord bottoms.

It should be mentioned here that in contrast to the relatively younger volcanic formation of the Kaumajet Mountains, all the Torngat region north of Nachvak Fjord is of metamorphic rocks, which appear to be the extreme easterly extension of those of the Canadian Archean Shield. They are predominantly acid gneisses and granulites, and in the Kangalaksiorvik and Komaktorvik area types rich in garnet and pyroxene were of frequent occurrence. The region has been subject to extreme compression, and the structures rendered largely vertical, along a mainly north-south direction, by ancient mountain-building forces. As is so often found elsewhere in the Canadian Shield and in other Archean areas, the whole complex has been shot through with black basic dyke-rocks, which at the coast form the striking display earlier referred to. But it is not to this early epoch of orogenesis that we can attribute the present mountain forms of the Torngat. The ancient folds of that epoch had long since been worn down to a peneplain, probably even previous to Cambrian times, and the area much later domed up to an elevation probably very much above that of its present highest crests. Whether seen from the air off-shore, or from a peak of the coastal groups, the accordance of crest-lines of the Central Range in particular, where the old erosion surface stands highest, is remarkable. Owing to extensive dissection in the coastal belt only small isolated portions of that surface remain, but it was in general lower in elevation and extended eastward far beyond the present coast-line. On the western side the peneplain surface descends gradually to sea-level at the waters of Ungava Bay, and still retains its glaciated though not deeply dissected character. Being composed of the same ancient gneisses and schists, its internal structure is mountainous, but its external form or geographical structure is that of a gently sloping plateau.

(*To be concluded*)

A FURTHER JOURNEY THROUGH THE LIBYAN DESERT:

Continuation from the August Journal of a paper read at the Evening Meeting of the Society on 29 May 1933 by Mr. W. B. K. Shaw on behalf of

MAJOR R. A. BAGNOLD, Royal Signals

6. DESERT RAINFALL

There are two important questions which must be answered before the archaeological history of the Libyan Desert can proceed much farther. What is the volume, distribution, and frequency of the rainfall at the present day? And how has that rainfall altered in the past? I am not going to attempt to discuss either question, but the following ideas may possibly be of interest. The present rainfall and climate of great uninhabited areas are difficult to determine, for they require continuous records to be taken over a long period. Unfortunately no automatic recording instruments exist which would be capable of being installed far out in the heart of the country by some traveller, and which would continue working till visited again a year or more afterwards.

The only evidence of modern rainfall we can gather is from (1) the reports of travellers, whose area and period of observation are very small and whose journeys are usually confined to one period of the year; (2) the observation of surfaces which show signs of apparently recent rain runnels, flood channels, etc., having vertical uncrumbled banks; (3) the present distribution and type of the existing vegetation (other than that which draws its water from artesian sources at or near the oasis-depressions); and (4) the legends of the Badawin.

The reports of travellers might yield much information as to winter rainfall in the north, if they were all collected and searched, but very little in the south, where the rainfall would presumably be confined to the hot summer months when no traveller or Badawin would be about. North of lat. 23° rainfall in the desert far to the west of the Nile is by no means negligible. Rohlfs was rained upon for forty-eight hours in 1874 at Regenfeld. Prince Kemal el Din found fresh grass and water standing in pools for a wide area round 'Uweinat in 1926, and reported (from native sources) a great flood at 'Uweinat in 1927. In January 1928 I saw rain for twenty-four hours between Bir Terfawi and Bir Safsaf west of Aswan. In November 1929 flood water was standing in pools far to the west of Bahariya, and rain fell heavily the whole way thence to Cairo. Rain falls almost yearly in the barren desert west of Cairo. It is possible too that the rain records in the low-lying depressions of the inhabited Egyptian oases are not truly representative of the rainfall on the surrounding plateaux. The evidence of the desert surface is unreliable because it is uncertain what length of time elapses before wind and sand erosion and the crumbling effects of the violent daily temperature changes produce a visible effect on the fresh sharp-edged wall of a water-scour in mud or gravel, but the period is unlikely to be more than a few years. Areas of such fresh water-scouring are certainly found more often on the high plateaux, although they are only 100 feet above the plain, than on the plains themselves.

Apart from the grassy vegetation growing on sand, which I will discuss

separately, evidence of desert rainfall can be obtained from the existing desert type of vegetation, excluding any whose water supply may be traced to permanent artesian sources, or, near the Nile and the coast, to dew. Fortunately it is usually easy to eliminate the former because most vegetation outside the oasis areas occurs on or near high plateaux several hundred feet above the possible level of the general water-table. Particularly interesting are the "false oases" which we discovered, the one west of 'Uweinat and the other in the Sarra Triangle. In the latter case especially, the volume of water must have been very great to form so large a lake and to maintain it for a sufficient time, certainly more than one season, to account for the breeding of the dense masses of freshwater shell-fish now left on the surface of the ground.

From the legends of the Badawin very scanty information can be got, but it is interesting to note that modern exploration has tended to remove from the map wells and oases reported from native sources to exist, rather than to add any new wells. As the network of travellers' routes, along which altitudes have been taken, continues to grow, it becomes less and less likely that any more true, that is artesian, oases will be discovered. So it is reasonable to suppose that the old native wells and "lost oases" were the result of mere accumulations of rain-water in basins of impervious rock or clay similar to that which must have occurred fairly recently near Gebel Hadid in the Sarra Triangle. Except that the mountain mass of 'Uweinat itself makes the local rainfall probably more frequent, we can take the 'Ain Duwa area as an example of the progressive effects of heavy rainfall on a large rock or clay basin. First as in 1927, a big lake is formed, but when this disappears water is still obtainable below the surface in large quantities for several years: *e.g.* in November 1932, five years afterwards, the pool in the rocks is still apparently inexhaustible, although, judging from the state of the mountain vegetation no rain has fallen in the meantime. In this connection it may perhaps be remarked that of the many legends of Zerzura three things are repeated: (1) A lake is mentioned; (2) the site varies from place to place over the desert; and (3) no oasis can be found.

The appearance of grass areas is interesting. Though it is quite evident that an appreciable quantity of rain does fall over the Libyan Desert, it is only on the western and southern outskirts that it falls frequently enough to maintain any but the drought-proof type of vegetation, which survives in specially favoured spots where water accumulates in pockets of impervious material. As one approaches the outskirts where rain falls with greater and greater frequency till it becomes annual, there comes a zone along which the first of the grasses, etc., appear, either as growing plants or dead remains. The fact emerges that in every such zone these grasses are only found growing on the undulating surfaces of accumulations of blown sand. This is particularly evident in the south, where for a depth of 150 miles the central tongue of sand-engulfed country running down between long. 24° and long. 26° is covered with grasses, while immediately on both sides the ordinary desert surface of gravel and coarse immovable sand covering powdered clays and muds is quite bare of life. We find the same thing north-west of Tekro and again in the Mourdi Depression. It is a difficult thing to compare the effect in the northern coastal extremity of the desert owing to the lack of sand areas and to the interference with natural conditions caused by cultivators.

The relative ease with which grass crops can grow on areas submerged by sand accumulations possibly explains the apparent greatly increased density of ancient habitation sites among the dunes in the now true desert south-west of 'Uweinat, and also the sites found by the late Colonel de Lancey Forth far to the north in the Sand Sea near Ammonite Hill, the querns and stone circles found by us in 1930 to the north of the Gilf Kebir at the southern limit of the Sand Sea, and the unaccountable stones we found in 1929 and 1930 lying about on the tops of whalebacks far above the surface of the ground. That these "people of the dunes" made extensive use of grinding mills appears to indicate their comparatively recent date. It is interesting to speculate upon how much rainfall additional to that of the present day would be necessary to support again the grain which once grew on the sand. Presumably after a certain ascertainable period without rain, the seeds lying dormant in the sand would be incapable of germination, and if rain falls more seldom then once in this critical period it will produce no crop of vegetation unless a sufficient supply of seeds is always being transported by the prevailing wind from the north and north-east. Possibly quite a small increase in frequency might bring rainfall within the above critical period, and produce intermittent vegetation over large areas of sand country now absolutely barren.

The following note should have appeared last month with the section on Sand and Sand-Dunes:

"On the map which accompanies this article an attempt has been made to illustrate the various sand formations to which Major Bagnold refers. The following types are indicated: (1) Elongated *seif* dunes, either as isolated narrow lines such as the Abu Moharik, or when forming a dune-field as in the Sand Sea. (2) *Barchan* dunes. (3) Country completely submerged by sand in which the underlying rock does not appear, *e.g.* the great Sand Sea south and south-west of Siwa. Over the whole of this area *seif* dunes have been indicated, although except along travellers' routes their existence is largely a matter of conjecture. Similarly the limits of the sand-submerged area are only approximate. (4) Sand sheets. (5) Sand undulations. Major Bagnold classes whalebacks and undulations under one head, but it is the latter sub-type which forms the large area around lat. 18° long. 25°. The whalebacks, as Major Bagnold notes on p. 125, are to be found mainly in the Sand Sea.—W. B. K. S."

7. GEOLOGY AND GEOMORPHOLOGY OF THE SOUTHERN LIBYAN DESERT. By K. S. SANDFORD.

1. *Cairo—'Uweinat—Selima*

(*a*) *Cairo—Kharga.*—Most of this country is geologically well known, but some points of new interest were observed along the route followed by the expedition. Among them may be noted:

(1) An acutely folded region of Middle Eocene rocks, in the main domal structures, with a monoclinal flexure plunging in a westerly direction, is centred about 75 km. along the line of route from Camp 1. The general trend of the main axis is N.E.–S.W. The folds mark a northerly continuation of broken ground already shown on the map. The structures were not repeated on so intense a scale anywhere else along the route, and they are distinct from

the disturbed strata in the Eastern Desert with which I am familiar.[1] Taken in conjunction with some folds identified in the Nile Valley recently, a description of which is now in course of publication, this locally acute folding may be associated, in my opinion, with a south-westerly prolongation of the Wadi Araba–Qalala folds of the Red Sea.[2] The hard and soft beds have been unerringly picked out by the sand blast of the prevailing wind, and some highly arched ridge-and-furrow country results.

(2) An unexpectedly wide westerly extension of the area occupied by, or containing relics of, Pliocene rocks of the Nile Valley facies impresses the fact that the 200-m. contour gives a far more accurate idea of the extent of the Pliocene sea than might have been supposed. In other words, the wind-blast, though severe—as every rock surface testifies—has, in the aggregate, reduced the level of the country less than might have been expected. The lack of marked wadis in this region at any distance from the Nile is only in part attributable to the effect of desert denudation.

(3) Along the flanks of the Abu Moharik dune, chains of wind-eroded basins have been produced in the Lower Eocene strata. North of Kharga the hard limestones and silicious "melon-beds" of this series have been denuded into surfaces virtually impassable to cars seeking a route across the direction of the prevailing wind, and therefore across the grain of the country. The purer limestones have been cut into countless rows of stream-lined ridges, with sand-filled hollows between them. The interbedded lines of melons have become overwhelmingly concentrated by the destruction of the intervening limestones.

(*b*) *Kharga—'Uweinat.*—The geology of Kharga is intimately known thanks to the work of the officers of the Egyptian Survey Departments.

(1) *The Nubian Sandstone.*—We left the depression on Nubian Sandstone, and on that formation we remained for by far the greater part of the journey to El Fasher, and thence to Wadi Halfa. When the full geological account is written, evidence will be produced to show, among other things, the following:

(i) A regular succession of beds may be recognized over an enormous area of the Nubian series.

(ii) Over the whole area these beds are probably of Mesozoic age.[3]

(iii) The site of the discovery of Carboniferous plants in "Nubian Sandstone" at Karkur Murr, 'Uweinat, by Prince Kemal el Din's staff was visited and a small collection of plants made. It was noted however that these beds are marked off from the overlying sandstones of the "normal" Nubian series by a distinct break in the sequence. There is no proof that the sandstone beds are of Carboniferous age except in this neighbourhood; therefore generalization from the discovery of the plant remains is not permissible.

[1] Cf. W. F. Hume, 'Rep. Proc. Internat. Geogr. Congress,' Cambridge, 1928, p. 213; also K. S. Sandford, *Geogr. J.*, vol. 72, 1928, p. 154.

[2] The alignment may, of course, be a matter of coincidence: if this is so we must admit that the domal structures of the Eastern Desert occur in the Western, and in an abnormally acute form.

[3] Cf. G. V. Colchester's discovery of plant remains at Jebel Dirra, near El Fasher, claimed by W. N. Edwards to be of Cretaceous age: *Abs. Proc. Geol. Soc. London*, No. 1143, 1926, p. 28. We found fossil wood, yet to be identified, in widely separated areas.

The "false oasis" of Gebel Hadid

Conical hills and remains of horizontal stratum of Nubian sandstone near Camp 6

Hills south-west of Camp 7: hard silicious rocks dissected by water erosion

Yerguehda Hill; site of rock paintings and stone platforms

Clayton's "craters" (right background) from the west; in foreground granites of sub-Nubian complex; on the left Nubian sandstone with lava capping

(iv) The hills encountered after leaving Camp 7 consist of extremely hard grey and black silicious sandstones or quartzites, which are covered by a thick basal conglomerate of the Nubian series. A fault delimits the western side of the range. As far as I know, this is the most northerly exposure of the pre-Nubian rocks yet located in the vicinity of the western frontier of Egypt.

(v) Not only is there a strongly marked basal Nubian conglomerate, but intra-Nubian conglomerates were noted at a number of points between Kharga and 'Uweinat, and, later, in the Sarra Triangle.

(vi) There is little sign of folding between Kharga and 'Uweinat, and the only major fault is responsible for the marked change in topography described above. The rest of the country is uninspiringly flat and "sawn-off" by wind-erosion, especially to the south-west of Mr. Harding King's farthest point. North-east of the black hill that marks his turning-point the dissection of the country is less complete in the direction of Kharga and the scarp of Lower Eocene rocks that runs thence to Dakhla. The monotonous desert is there replaced by "haystacks" and their half-ruined stumps, conical hills and flat-topped ridges.

(2) *Granite and gneiss*.—At a point about 50 km. north-east of Camp 8 the sub-Nubian plain of the ancient gneisses, schists, marbles, quartz, and associated rocks was encountered. It may be traced thence in a loop round the south-east corner of the 'Uweinat massif almost as far as Sandara Hill on the west and Yerguehda Hill on the south. The rapidly changing members of the series have been acutely folded and compressed on E.N.E.–W.S.W. lines, the angles of dip generally being northerly and rather steep. Their upturned edges have been reduced to virtual flatness before the Nubian Sandstone was laid down on them. It should be noted that the Carboniferous rocks of 'Uweinat are in no sense whatsoever a member of this ancient series, but certainly overlie them unconformably. Isolated peaks like Gebel Kissu, Shazzi East, the western part of 'Uweinat, and other masses are made of holocrystalline deep-seated rocks that have not been folded in common with the metamorphic series already described, and in fact are younger than those rocks. They stand as islands in a sea of Nubian Sandstone, projecting from a floor of the ancient complex. Except perhaps in 'Uweinat the unfoliated igneous rocks do not seem to be separated from the encircling Nubian beds by fault or flexure. They are evidently older than the Nubian series, and, in all probability, than the Carboniferous sandstones, but younger than the orogenic phase that metamorphosed the fundamental complex of igneous rocks and ancient sediments. The similarity of petrological composition of the pre-Carboniferous complex of this remote region and of the rocks of the distant Red Sea Hills seems to be marked.

(3) *Volcanic activity*.—The identification and investigation of the group of hills of volcanic origin north-east of 'Uweinat, previously discovered from the air by the late Sir Robert Clayton East Clayton and his friends, has already been described briefly in *Nature*,[1] and nothing need here be added to that account except to say that the craters are the most spectacular members of an associated group of features of volcanic origin. They include thick lava sheets now capping isolated hills from Ras el 'Abd ("Chunk Hill") on the east side of

[1] Vol. 31, 1933, p. 46.

the 'Uweinat massif to Peter and Paul near the Gilf el Kebir. The former existence of hot springs is well displayed over a wide area. All trace of active vulcanicity has long since faded away from this region, though it is the last event of its geological history, probably of later Tertiary age.

(*c*) *'Uweinat—Selima.*—This country has become well known thanks to the pioneer work of Mr. H. J. L. Beadnell[1] and Mr. P. A. Clayton. It consists exclusively of Nubian Sandstone once Gebel Kissu and its environs are left behind. It forms a part of one of the largest of the sand-sheets described by Bagnold.[2]

2. *The Sarra Triangle*

West of Sandara Hill the region consists of Nubian Sandstone. Sandara Hill is the central point of another volcanic field. Paterson and I were able to visit most of the main outcrops and to plot their approximate positions. In most respects they are analogous to those already mentioned above and very briefly described in *Nature* (*loc. cit.*).

As far west as Sarra Well the country is flat and rather uninteresting, although the succession of beds and intercalated conglomerates of the Nubian series is well displayed. Between Sarra and the eastern scarps of Tibesti on the west and Tekro on the south lies a more elevated region, probably contiguous with the Jef-Jef plateau. Slight changes of dip entirely control the topographic features of the region, and close attention to dip and strike makes the difference between virtually impassable and comparatively easy going for cars. On the whole the structure of the western part of the triangle is most readily explained as a great dome, and further detail may be omitted here. Dips towards the depressions that flank the eastern scarps of Tibesti are locally very clearly defined.

It emerges therefore that water passing from Tibesti into the Nubian Sandstone must make its way up the dip of the beds and through the widely exposed regions of highly folded rocks of the fundamental complex before it can pass eastward to the natural or artificial wells of the Egyptian sector of the Libyan Desert.

The flatness of the Jef-Jef plateau and of many other elevated regions of Nubian Sandstone between Tibesti and the Nile Valley suggest that an old land surface or peneplain has been dissected almost to the point of disappearance over the desert belt.

3. *'Uweinat to El Fasher*

Between Yerguehda Hill and Wadi Hawa nothing but Nubian Sandstone was encountered. From Erdi southward the frayed eastern edge of the old plateau referred to above seems to be recognizable, pierced by the Mourdi depression (a corridor leading towards the Chad basin that seems to mark a change in the strike of the beds), and by Wadi Guroguro. In the latter an unusually thick-bedded stratum of sandstone, which was first noted on the south side of Mourdi, has weathered into castle-like outliers.

From Wadi Hawa to Kutum the rocks of the fundamental complex alternate with outliers of Nubian Sandstone, which virtually disappear before Kutum

[1] Cf. *Geogr. J.*, vol. 77, 1931, pp. 245–250 and map.
[2] *Ibid.*, vol. 78, 1931, p. 31.

is reached. Thence to El Fasher the geology of the country is known from the official surveys of Mr. G. W. Grabham and Mr. G. V. Colchester. The fundamental rocks are dominant, and thick basalts are locally prominent.

The Erdi–Ennedi country which we entered at Mourdi and Guroguro is vividly described by Hassanein Bey[1]: to the east of its deeply indented edge lies a region of sand sheet which evidently extends to the line of southern Libyan oases, El Atrun–Merga–Wadi Hussein. In this wide country, as in other sand sheets described by Bagnold, arid denudation seems to have reached a state of almost perfect maturity or old age. Extremely little rock remains exposed to the sand blast, and there is a balance between minor erosion and deposition in hollows. I suggest that the term "desert peneplain" or "surface of maximum denudation" may be applied to all of them. They should be clearly distinguished from sand seas, *i.e.* regions of mass accumulation of sand, for they are not predominantly zones of deposition.

As Wadi Hawa is approached, or south of Guroguro however, accumulation of sand becomes dominant; but, as Bagnold has pointed out, *seif* and *barchan* dunes, *i.e.* "living" sand, are virtually absent. South of the wadi all the sand is old, and much oxidation of iron salts has taken place. The desert belt is soon replaced by dense scrub and open rolling grass land, and, nearer Kutum, torrents that probably run in most years are bordered by magnificent and shady trees.

In the Kutum district the country passes into a mountainous terrain culminating in Gebel Marra and the highlands of French territory. This may not have suffered from a severely desert climate at any time, but it should be remembered that the *old* sand, now vegetated and known as *goz*, approaches it on the north and sweeps southward along its east side to El Fasher and far beyond, into south-eastern Darfur and Kordofan.

4. *El Fasher to Wadi Halfa*

Rolling *goz*, between hills of the fundamental complex and traversed by fertile wadis, extends northward from El Fasher. Outliers of Nubian Sandstone appear a little to the north of Mellit, but this formation makes its first major appearance in the Berti (Tagabo) Hills, capped with extensive sheets of basalt, and may be followed to the Meidob Hills farther north. Here again basalt sheets are prominent, some of the flows around Malha crater being of extremely fresh appearance. It should be noted that basaltic lava has actually flowed into this crater, descending its side from above, cascading over its rim from an adjoining vent which is not now visible (*i.e.* it is hidden under its own lava). No lava accompanied the final explosion of the Malha crater within the crater itself. The district was the subject of an official geological report by Mr. G. V. Colchester.

The high sandstone plateaux, locally capped with basalt, here and there reduced to conical hills, may be traced from Meidob northward to the Teiga and Tageru hills: outposts of it, devoid of basalt, approach the south side of Wadi Hawa. North of this remarkable wadi the *goz*, the red sand, and the dissected plateaux are left behind, and the real desert is encountered once more.

The southern Libyan Desert thus lies at the foot of a fretted scarp of Nubian

[1] 'The Lost Oases,' London, 1925.

Sandstone that may be traced from Tibesti through Jef-Jef, Erdi, Ennedi, to the hills south of Wadi Hawa; from our first to our second points of crossing of that depression detached plateaux may be traced along the southern side at no great distance. From Gebel Tageru to the Nile I believe I am correct in stating that the plateau might be traced in a number of disconnected hills. Along the Nile itself I think, judging by what I have seen, that the plateau rim may be identified especially in the hills between Abu Hamed and Kareima. On the north 'Uweinat and the Gilf seem to continue the eastern edge of the old high ground, and its main mass might be discernible as far as the Fezzan. Eastward from 'Uweinat outlying patches of high ground stretch along north and south sides of the Selima route until the great sand sheet is reached. I suggest that the southern Libyan Desert is in fact a hole gouged out of a very old land surface, made of Mesozoic strata (for the greater part of continental origin), probably reduced to subdued relief in early Tertiary times.[1]

From the second crossing of Wadi Hawa to Wadi Halfa sand and Nubian Sandstone prevail. Small outcrops of dolerite occur sporadically. Markedly eastward-dipping strata lead from the western sand sheet into the El Atrun-Merga depression. This, like Tekro, Laqiya, and some other of the depressions (with or without available water) contains freshwater deposits in the lower parts: at Tekro in particular these were highly fossiliferous.

The contrast between the western "desert peneplain" and the rough, "untamed," rocky desert between Merga and Laqiya is very remarkable. The rugged country also continues north of Laqiya for about 50 miles before the borders of the Selima sand sheet are encountered. This wide region of rocky desert is considerably modified by gentle folds, which locally become strongly pronounced. The Laqiya pools owe their situation to differential erosion of marked anticline-syncline structure, and the way out of the depression, such as it was, owed its direction to the pitch of these folds. The undulating beds of the rugged country display the successive beds of the Nubian series to advantage, and wide areas of "petrified forest" attract attention.

The incidence of gentle flexures marks broken ground in the sand sheet south-west of Selima, and defines the position of the oasis and its beautiful pool. Thence the sand sheet continues eastward until high sandstone "islands," giving place to a plateau, mark the edge of the Libyan Desert. The Nile, approached from this direction, comes suddenly into view, hidden in a comparatively narrow trench in the sandstone plateau, which continues on its east side, giving place southward to the fundamental complex in the high ground of the Second and Third Cataracts. The first view of the Nile is something of a shock: it seems absurd and incredible that a great river should exist in such a waste.

The known geological sequence in the Southern Libyan Desert may be given provisionally as follows:

Tertiary and post-Tertiary ..	8. Volcanic outbursts, lavas, and hot springs.
Mesozoic	7. Nubian Sandstone.
	6. Unconformity.

[1] The bearing of this statement upon recent discoveries of Older Tertiary "lake beds" in the Nile Valley near Albana is interesting. See *Abs. Proc. Geol. Soc. London*, No. 1254, 1932, p. 17, and *Geol. Mag.*, June 1933.

L. Carboniferous	5. Plant-bearing sandstones.
	4. Unconformity.
(?) Later pre-Cambrian ..	3. Unfolded holocrystalline rocks.
Pre-Cambrian, Archaean ..	2. Intense folding and metamorphism.
	1. Ancient sediments, gneisses, and igneous rocks.[1]

8. PAST CLIMATE AND EARLY MAN IN THE SOUTHERN LIBYAN DESERT. By K. S. SANDFORD.

Many have been the discussions on the inhabitation or otherwise of the present deserts by Palaeolithic Man. The view that I would submit as a result of this expedition is this: that Palaeolithic implements are liable to occur almost anywhere in the Libyan Desert, but there are certain wide areas where they are most unlikely to occur, from which, in fact, they appear to be completely absent. These areas are the sand sheets, which I have suggested might be termed desert peneplains. They are, I believe, the very growth-points of the modern deserts, and of great age. They lack Palaeolithic implements not, I think, on account of the total destruction of the stones, but because the regions were unattractive or uninhabitable, even for hunting. It is significant that the oases in or near the sheets are destitute, or virtually so, of such implements. Merga and El Atrun produced none at all, Selima one or two probably of Middle Palaeolithic Age. In the Laqiya depressions certain types abounded (see *infra*, p. 220), but this territory is neither in nor near a sand sheet.

Moreover implements occur in some regions of fairly low elevation even in the heart of the desert, where the water table is now fairly near the surface, and may formerly have nourished springs; but I cannot recall their occurrence in such a situation within a sand sheet.

As a general rule, height seems to have been favourable to Palaeolithic Man, just as the high ground at the present day stands the best chance of receiving rain. Ground that is high, or adjacent to some elevation, and is still rocky, may reasonably be expected to bear implements, though they may be sparse.

With these factors in mind we may survey some of the ground traversed. Between the Nile and Kharga implements were found sporadically along our line of route, which lay for the greater part on high ground that still receives occasional rains. The whole of the region was probably well within the range of Nile Valley Palaeolithic people.

Along the route from Kharga to 'Uweinat scarcely any Palaeolithic implements were found until we reached the high ground near Camp 7: on its east side they abounded, on its west lies sand sheet, and we found not a single specimen.

As the high ground of 'Uweinat was approached Lower and Middle Palaeolithic implements were found again, notably round the foot of Gebel Kissu and (a few) near Clayton's craters. I have no doubt that they will be found near and on the Gilf.

The Sarra Triangle was barren until the Tibesti scarps were well in sight: Shaw then found a magnificent Lower Palaeolithic coup-de-poing and a few

[1] For the mutual relations of these in the Red Sea Hill complex in particular, see W. F. Hume, *Abs. Proc. Geol. Soc. London*, No. 1238, 1931, p. 18.

other implements were also collected. Tekro provided none. I have little doubt that the leisurely inspection of the Jef-Jef country would produce a good collection.

Lower and Middle Palaeolithic implements were found at Yerguehda Hill and on the north scarp of the Mourdi depression: eastward, they disappeared.

It seems probable that until Middle Palaeolithic times some connection between Tibesti and the Nile Valley was feasible. From Kissu eastward a few implements were found at intervals as far as the edge of the sand sheet, and at Selima a couple of poor specimens.

In point of chronological sequence the most interesting fact that next emerges is that Laqiya and its immediate environs are littered with countless thousand implements. These appear to be exclusively of later Middle Palaeolithic type, including the earlier forms of the industry known as Sebilian in the Nile Valley. The plains on the west are virtually devoid of them, but they occur in depressions, now dry, in the immediate vicinity of Laqiya, but on its Nile-ward side. The water-level in both wells, and the ground for at least a mile round them, proved to be considerably below the lowest surface on which the implements lie: *i.e.* some scooping out of the ground by wind and lowering of the water table has since taken place.

It is abundantly clear however that the oasis was already cut, probably by wind, almost to its present form at the time of its apparent "overcrowding" in late-Middle Palaeolithic times. Laqiya seems to have been the only oasis of the southern Libyan Desert that was so inhabited: the others, if ever occupied, were already abandoned, even Selima. It is gratifying to find that these observations in the desert-belt are in accord with evidence collected in adjacent parts of the Nile Valley, where lay Man's ultimate refuge.

Perhaps it was changes of this sort that set other human communities in motion on the west side of the great desert, *i.e.* along the fretted scarp of the western plateau, probably from the Fezzan southward through Tibesti to Wadai. At 'Uweinat Hassenein Bey and, later, Prince Kemal el Din's party found rock pictures which Breuil[1] claimed as of Bushman type: subsequently rock drawings have been found in a number of parts of the massif by almost every party that has visited it. In no instance were implements found associated with painting or drawing. Now the remarkable paintings of Yerguehda Hill have been added to the list. In the plain below and over the rocks adjacent to them coarse chippings of indefinite type and age were found: they may belong to a period long posterior to the paintings. Especially in the plain immediately below the paintings however, and on the sandy floors of the rock shelters themselves, we found minute implements that reminded me strongly of late Palaeolithic African workmanship. I am convinced that paintings and implements are here associated, and it seems probable that both point in the same direction.

I was surprised to find this industry again at Beacon Point, mixed with slightly larger and cruder types probably of slightly greater age, and I have no doubt that it will be found at intervals all along the hills. It is at least fairly evident that in later Palaeolithic times people were passing along the east side of this "backbone of Africa," as indeed they are to-day. Some of these people

[1] Cf. *Revue Scientifique*, vol. lxvi, 1928, pp. 105 *et seqq.*; and in 'Afrique,' *Ed. Cahiers d'Art*, Paris, 1931, pp. 97–100, South African analogies are indicated.

may rarely have made their way to the Nile, but they left no *painted* drawings behind them, so far as we are aware.

South of the latitude of Guroguro not a single Palaeolithic implement was found. North of the Wadi Hawa is sand sheet, south of it is the old sand. The precise age of accumulation of the latter is not yet known: older Palaeolithic implements may lie below it, but younger types do not seem to rest upon or among it. Newbold,[1] on the other hand, has shown that rock drawings, some of them probably very old, occur within the area of old sand[2]: it has not yet been proved that any of them are Palaeolithic, but it seems probable.

The concentration of later Middle Palaeolithic implements in Laqiya and other evidence points to aridity having become rather rapidly worse in the north-western Sudan at about this culture-stage. It is possible that some of the mid-desert oases like Merga and El Atrun were only cut at this time, and that the old sand may also be attributed to it. This however is largely a matter of speculation. It is certain none the less that the water table has since risen above the depth of former wind-scour, and that many of these pits in the desert have been occupied by lakes, with freshwater fauna, that have since disappeared. Perhaps we may couple with this the frequent occurrence of water-laid deposits in depressions far out of reach of the water table, *i.e.* nourished by surface run-off. In the north we found Middle Palaeolithic implements in old gravels deposited by water draining into wind-formed basins. In the south major lines of drainage from western Darfur have virtually re-established themselves in broad eastward-draining courses across the old sand.

In the north and west there may well have been more than one partial relaxation of extreme aridity, especially on the higher ground; one such Shaw dated by purely archaeological evidence to a probable Neolithic age (see p. 222). With this may be discussed the temporary colonization of the western sand dunes, and of Wadi Hawa, in geologically very recent times (see p. 224).

One more indication of a formerly humid climate of a region now arid merits brief attention here. South of the Sudan border—I can recall no example farther north than Clayton's craters—concentrations of iron (and probably manganese) salts in a tough material like a dried clay are common. They are absent from the sand sheets, and are particularly thick along the western borders of the desert. In Guroguro and other localities they exceed 6 feet in thickness. Everywhere they are being actively denuded, not formed. They are thickest above mottled shales, and are absent from the surface of silicious sandstones. Sections of shales show that there is an upward concentration to form the layer, and leached, impoverished rock below. Where the bed is thick it often possesses a pisolite-like structure.

To conclude, I was unable to distinguish this material in any respect from a substance exposed near Omdurman which Mr. G. W. Grabham showed me there: he has long regarded it, I understand, as a form of laterite. From what I have seen in the country described above, I should certainly agree with him.

[1] *Antiquity*, vol. ii, 1928, pp. 261–291; see also *Sudan Notes and Records*, vol. vii, 1924, pp. 43–92.

[2] As at Zalat el Hammad, see Newbold, *ibid.* See also Breuil, 'Afrique,' *loc. cit.*, for opinion as to the age of these pictures.

I think we may safely regard it as an indication that a hot and at times very humid climate formerly obtained over much of the Sudan that is now a desert. I found no means of fixing its age with relation to Palaeolithic Man, but from general observations I do not think it is likely to be younger than the close of Lower Palaeolithic times. Some implements of advanced Lower Palaeolithic type bear an ochreous crust that one associates with the "laterite": this is slightly developed on primitive Middle Palaeolithic implements, and, as far as my experience goes, it occurs on none of younger type from the area under discussion.

The following purely provisional sequence of climatic changes in the southern Libyan Desert may be given here to summarize the indications given above. No attempt can be made here to supply the full evidence: when the whole of it is available the following scheme may be modified:

5. Mesolithic, Neolithic, Recent.	Some watercourses established across *goz* from mountains towards Nile. Alternations of rainy and desert periods in country between W. Hawa, central oases, Sarra Triangle, and western mountains.
4. Later Palaeolithic	The sandy *goz* south of W. Hawa probably recolonized by plants, but probably desert at outset. Oldest rock pictures (?).
3. Lower Sebilian	At close aridity complete, all oases abandoned, desert virtually uninhabited except along borders, arid area at its maximum (?).
2. Middle Palaeolithic	Major deterioration of climate, "laterite"-forming climate ended (?).
1. Lower Palaeolithic	Virtually whole of present desert area available, at least for hunting, except perhaps inner parts of present sand sheets. "Laterite"-forming climate still persisting between W. Hawa, central oases, Sarra Triangle, and western mountains (?).

9. NEOLITHIC AND LATER TIMES. By W. B. K. Shaw.

For lack of space and illustration these notes can be little more than a catalogue of finds; I hope later on to deal with the subject at greater length elsewhere. Our rather hastily gathered material was all from the surface and we have not therefore any evidence from stratigraphy. But I doubt whether on the high desert excavation would reveal much. In places the moving sand formations must have swamped temporarily or permanently an ancient site, but elsewhere it seems that the sand-charged wind is slowly grinding down the face of the desert and that the implements which record man's occupation are being lowered therewith. A small excavation, in the dune country south-west of 'Uweinat, for example, would help to settle the question.

South-west of Kharga on the way to 'Uweinat we found a number of shallow mud-pans which Bagnold has mentioned on p. 105. Around their edges were many querns and grinders, fragments of ostrich shell, and a grooved piece of sandstone perhaps used for shaping wooden shafts;[1] also three leaf-

[1] *Cf. Antiquity*, September 1928, p. 280.

shaped blades of worked sandstone and a triangular scraper of tabular flint, all of a type which in the Nile Valley one associates with the Predynastic period.[1] Between 'Uweinat and Sarra, and again west of Sarra, we found similar pans with implements nearby.

The next area of interest lay between Tekro and 'Uweinat. Beginning at a distance of about 75 miles from Tekro and continuing for some 80 miles through a country of billowy sand and later of parallel *seif* dunes was a succession of ancient sites. Their appearance of untidiness first catches the eye; the otherwise neat desert is littered with fragments of stone. These are numerous querns, grinders, a few sandstone hoes or axes, fragments of ostrich shell, quartzite flakes and some sherds. Here we found one, and at lat. 16° 35′, long. 25° 41′, and again at lat. 17° 23′, long. 25° 55′, two more of those curious axeheads of diorite which seem to be a peculiarity of the south Libyan Désert.[2] On our detour to the east from the Mourdi Valley and again on our way south-east to the Wadi Hawa we found an occasional quern or grinder, but not in the quantities noted above.

At the mouth of the Wadi Guroguro were many very crude drawings scored on isolated pillars of rock. They showed a number of almost indeterminate animals, perhaps cattle and camels, and some geometric designs, and are probably of very recent date.

Previous travellers who have reached the Wadi Hawa have found pottery and implements along its banks and we followed it westwards for some miles with this object in view. Where we struck it first the north bank was strewn with potsherds, and we found querns and grinders, one or two celts, and another grooved polisher. To the west we were less fortunate; the north bank is ill-defined and a covering of grasses hid the objects of our search. On the north side of the wadi where we finally left it were some low hills of igneous rock and on them a very large number of stone tumuli. In size they varied, but the average was perhaps 3 to 5 yards across and 4 to 5 feet high. They were so constructed as to form a small, central, vaulted chamber, but we could not tackle an excavation. Such grave mounds are common enough over northern Kordofan and Darfur. Approaching the Wadi Hawa again on our way north from El Fasher we came upon the usual querns, grinders, and potsherds. These continued north of the wadi and 60 miles west of Bir Natrun we collected a fine pot, almost spherical in shape and with a design of impressed basketwork.

For the rest of the journey there is little to remark except the site 60 miles north-west of Wadi Halfa where in addition to querns, grinders, and ostrich shell we collected a number of worked flints of waisted or dumb-bell shape whose like I have not seen elsewhere. We found only one arrow-head during the journey, but more careful search might well produce further specimens.

In the area between Tekro and 'Uweinat, an arid, lifeless desert well over 100 miles from the nearest water, the evidences of human occupation in the past are surprising. The dozens of querns must imply the grinding of corn either grown locally or imported, and the stone celts were of a type that seemed far better adapted to agriculture than to war. Given a slight increase in rainfall

[1] *Cf. Geogr. J.*, November 1932, p. 371, for details of similar mud-pans found by Miss Caton-Thompson and Miss Gardner between the Nile and Kharga.

[2] *Cf. Antiquity, loc. cit.*, p. 276.

this country would probably grow crops. The sandy areas of Northern Kordofan and Darfur will support a shifting cultivation on a rainfall of not more than about 10 inches a year. And nowadays in autumn when the *gizu*[1] grazing is good the nomads bring their camels well up into the southern edge of the desert.

Our finds along the Wadi Hawa also indicate habitation in the past. The sherds resemble others collected on the edge of the desert by earlier travellers and classed as Meroitic. Meroe, first a subsidiary and later (*c.* 350 B.C.) the principal city of the Ethiopian kingdom, flourished from the eighth century B.C. to the fourth century A.D. These fragments probably represent the latter part of the period. It is fairly certain that the influence of Meroe spread south-west towards Darfur, perhaps by way of the Wadi Muqaddam and the Wadi el Melik. Both these wadis flood occasionally during the rains and for the rest of the year water may be got from wells along their beds. The Wadi Hawa is now waterless, but it is possible that in the past its state resembled that of these other wadis to-day.

Sandford considers that though in Lower Palaeolithic times conditions in the desert were genial enough, by the Middle Palaeolithic aridity had set in. We have thus to explain why climatic conditions were once favourable enough to allow settlement in country now desert. Has progressive desiccation since Neolithic times brought the true desert southward, pushing back the northern limit of the annual rains? Or do we find the explanation in a climatic oscillation that produced the Libyan equivalent of the pluvial periods of East Africa?

APPENDIX I: ORNITHOLOGY

R. E. Moreau

This expedition has provided practically the first information on the birds occurring in the great desert area of half a million square miles between Kufara and Dakhla Oases and the northern edge of Darfur. Forty-four specimens of birds were collected, with accurate localities. Of these, identifications of the first twelve have been furnished by the Zoological Gardens, Giza, Cairo, and Mr. N. B. Kinnear has found it possible to name twenty-nine of the remainder at the Natural History Museum. In addition we have the journal kept by Major Boustead who, although not an experienced ornithologist, has provided careful and interesting field-notes. Knowing my interest in Libyan Desert ornithology Mr. Kinnear has kindly put all this material at my disposal. It is hoped to deal with it in full in a future number of the *Ibis*.

By a fortunate chance the journey was made during the period when the migration of Palaearctic birds to winter quarters in Africa is still actively in progress. Major Boustead's notes show that there were only two days during the whole journey, namely, on the return from Tekro to 'Uweinat, that no birds were seen. At other times migrants, singly, in small parties and in flocks, for the most part Falcons, Swallows, Pipits, Wagtails, and various Warblers, were met with flying south. Frequently where the ground was broken odd birds, including Shrikes, Wheatears, Spotted Flycatchers, and even a Sedge-Warbler, were found resting among the rocks. The little patch of vegetation in the Tekro area and the northernmost limits of the Darfur steppe were thronged with birds.

[1] A word applied to the ephemeral vegetation of low grasses and herbs which springs up on the southern edge of the desert following the occasional localized rainstorms. From the Arabic—"to content with green pasture."

Several factors tend to diminish the number of birds observed on such an expedition as this. Ornithology is only a "side-line"; observations from a rapidly moving car are difficult; most migrants are small and inconspicuous; a large proportion of them certainly travel over beyond the range of vision. This particular expedition moreover traversed an immense area where vegetation and insect life are virtually non-existent. In view of these facts the number of migrants recorded is most remarkable. The indication is that a strong migration crosses the Libyan Desert for several hundred miles west of the Nile Valley. Support is given for the hypothesis put forward previously (*Ibis*, 1927, pp. 453–454, and 1928, p. 463) on the incomplete evidence then available, and contrary to probability, that the flood of migration crosses the Libyan Desert on a broad front, not concentrating on either the Nile Valley or the oases.

Many of the field-notes relate to Falcons, not apparently on migration, and give evidence that they were preying on the birds that passed by. This agrees with the observations made by Mr. H. J. L. Beadnell south-west of Dakhla (quoted in *Ibis*, 1928), and by itself points to small migrants being in abundance. In several places the desiccated remains of birds, including White Stork, Grey Crane, and Garganey Duck, were encountered, eloquent evidence of the risks run by migrant birds in that great desert.

As regards resident species, the expedition has provided only the second Egyptian record of the White-fronted Sparrow-lark, and has fixed the northern limit of the Darfur steppe fauna at about lat. 17° 30′ N. The specimens of the Desert Sparrow, *Passer s. simplex*, brought home were the first ever received at the Natural History Museum.

APPENDIX II: ENTOMOLOGY

N. D. Riley

The insects collected by Major R. A. Bagnold's expedition to the Libyan Desert are of interest in that they are the first to reach this country from the region. The majority are from the neighbourhood of the Wadi Hawa, the most southerly and fertile locality from which specimens were obtained. Of the 35 species represented no less than 13 were met with only in this area. After the Wadi Hawa, the Tekro Oasis, the Mourdi Valley, and the neighbourhood of the Gebel 'Uweinat were most productive, with 6, 4, and 4 species respectively. Bir Natrun produced only 2 species, and Sarra Well, Wadi Guroguro, Selima, Melit, Kutum, Laqiya, and Malha only 1 each.

The paucity of insects seems to be a very fair index of the barren condition of the country through which the expedition travelled, for at El Fasher in 1920 Admiral Lynes obtained in a short space of time a much larger and more varied collection; and in the Ahaggar mountains more recently Colonel Meinertzhagen met with a very much richer fauna. The only butterfly found was a solitary individual of the ubiquitous Painted Lady, west of Sarra Well, which is, however, of interest as it is considered that at least some part of the swarms of this species that annually migrate northwards across the Mediterranean into Europe originate in the Savannah area which borders the southern Sahara and also extends westwards towards Abyssinia.[1] Of the two moths also obtained *Utetheisa pulchella*

[1] Though only one specimen was collected Mr. Prendergast notes that Painted Ladies were seen frequently in all parts of the desert. While the lack of insect life is, as Mr Riley remarks, a fair index of the barren condition of the country as a whole, the disparity in the number of specimens from different localities is, I think, largely due to the relative time available for collecting.—W. B. K. S.

occurs throughout the Old World, and the other has a very wide distribution in the temperate zone. Of the other insects it can only be said on the whole that they are all well-known desert species, their affinities lying almost exclusively with the fauna of the Mediterranean basin or with that other highly interesting Eremian fauna characteristic of the desert belt that stretches from North Africa to Sind, thus linking Africa and India. Several of the species met with are known to occur throughout this region, and some indeed were encountered by Mr. Philby and by Mr. Bertram Thomas in the Rub' al Khali.

Probably the most interesting insect met with was the Desert Locust (*Schistocerca gregaria*), which causes periodic depredations in Northern Africa and South-West Asia, and the data on the distribution of its solitary phase in the Libyan Desert are of great value, since little information from that area has previously been available. They were seen at the Tekro Oasis on October 20 and 21, and at Merga and at Laqiya 'Umran on November 17. A full list of species was published in the August number of the *Entomologist*.

APPENDIX III: BOTANY

T. HUTCHINSON

On the two expeditions Mr. W. B. K. Shaw collected 46 species and 3 varieties of flowering plants. A list of the plants collected on the first journey was published in the *Kew Bulletin*, 1931, pp. 161–166, and a similar list of those gathered on the second expedition will appear in a forthcoming number of the same publication. These collections have added several species to the list of Sudan plants published by Broun and Massey in 1929.

As might be expected of such an arid region, all the plants belong to phylogenetically advanced families or genera and are especially adapted to very extreme conditions, many of them being annuals of short duration. For example, the most successful and advanced family of flowering plants, the Gramineae, is represented by 9 species and 1 variety, another advanced group, the Papilionaceae, by 6 species, while there are 4 species of Chenopodiaceae.

APPENDIX IV: CARTOGRAPHY, BAROMETRIC ALTITUDES, AND METEOROLOGY

R. A. BAGNOLD

Cartography, Navigation, etc.

Astronomical observations for position were taken at every camp by Shaw and Paterson with two $3\frac{1}{4}$-inch Watts Micrometer Theodolites lent by the Society. Greenwich Time for longitude determination was taken by Paterson from the Pontoise short-wave transmission. This signal, although almost unreceivable in England, was very strong throughout the whole area of our journey. The receiving set used was the same Phillips short and medium wave receiver which we used on two previous expeditions and which, though bolted to the running-board of one of the cars and carried across country for something like 12,000 miles, has never developed a serious fault.

A set of Sudan 1/250,000 map sheets was taken. Including some duplicates, over fifty sheets were required. They were carried flat in a light press made of ply-wood and canvas. At every halt during the day's run the course, noted from sun-compass and speedometer readings, was plotted by Craig directly on to the map sheet. The speedometer mileage readings were noted on the map along the plotted route at frequent intervals, and all observations, topographical, botanical,

geological, etc., and all aneroid readings, made by the various members of the party were linked to their correct location on the map by noting the speedometer readings of Craig's car. Sandford and Boustead were responsible for the topographical detail on each side of the route as plotted by Craig, their observations being correlated with his in the manner described above.

My sun-compass, described by Newbold in Appendix II of my article in the *Geographical Journal* of December 1931, was used throughout, the sun's azimuth being taken from Davis's Tables.

Barometric altitudes

Three Paulin aneroids were lent to us by the Society, and we carried in addition two pocket aneroids. The Paulins were kept carefully packed in a special padded case and readings were taken by Shaw evening and morning at each camp and at the midday halt, half an hour or more being allowed to enable the instruments to take up the local air temperature. Control readings were taken at eight stations of known altitude, at six of which the aneroids were checked directly against the barometer at the local meteorological station. The variations of the index errors of each instrument are shown in the following table. They may be useful as giving some idea of the errors to be expected in these instruments when carried across country in cars. The errors are shown in millimetres of mercury:

Station	*No.* 3	*No.* 5	*No.* 9	*Pocket instr.*
Cairo	+2·6	+2·6	+2·4	−24·8
Kharga	+2·0	+2·4	+2·0	−24·5
'Ain Duwa	0	+3·0	+1·6	−22·5
El Fasher	+1·2	+5·9	—	−23·4
Wadi Halfa	+1·5	+5·0	—	−27·0
Bir Murr	+1·0	+5·0	—	−27·0
Dakhla	−1·7	+5·0	—	−28·0
Cairo	−3·9	+5·4	—	−26·0

No. 3 behaved erratically after El Fasher, and in some cases its readings were discarded. On the whole the instruments agreed well among themselves.

The mean sea-level pressures corresponding to our aneroid stations were kindly estimated for us by Mr. Sutton of the Physical Dept., Cairo, from the daily isobar charts, and from his figures I have worked out the corrected altitudes. Unfortunately barometric data from French Equatorial Africa are not available, and it is perhaps stretching things a little far to expect very accurate results in the extreme west of the desert from data supplied by meteorological stations near the Nile, but Mr. Sutton does not think that the errors in the estimated m.s.l. pressures should be large. However the differences between morning and evening readings at the same station, especially in the west, were in most cases a good deal greater than can be accounted for by the corresponding changes in the estimated m.s.l. pressures.

One pocket aneroid was compared at every station with the Paulins, and its intermediate readings, taken every 10 miles or so along the route, were afterwards adjusted to correspond with the corrected station altitudes as determined by the Paulins.

At all the oasis-depressions in the southern part of the Libyan Desert aneroid heights have now been taken, and it is of interest to study the results tabulated below in connection with Dr. Ball's theory of the origin of the artesian water supplies of the desert (*Geogr. J.*, vol. 70, p. 105).

Height of static water-level in feet above sea-level

Selima

Newbold and Shaw, 1927	833
Bagnold, 1930	807 (the most reliable)
„ 1932	857

Laqiya Arba'in

Bagnold, 1932	1134

Laqiya 'Umran

Wilson, 1930	1062
Bagnold, 1932	1092

Wells in the El Atrun Oasis

Bir Milani, Newbold and Shaw, 1927	1715
Bir Natrun, Newbold and Shaw, 1927	1627
Bir Sultan, Bagnold, 1932	1655

Merga

Ball, 1925	1670
Newbold and Shaw, 1927	1653
Wilson, 1930	1634

For aneroid work the agreement between the various determinations is good. On the rather meagre data then at hand Dr. Ball (*op. cit.*, p. 115) predicted a height of 885 feet for Selima and 1280 feet for Laqiya: prolonging the contour on his map towards El Atrun would give one a height of a little over 500 metres (1640 feet) for that place. So the height observations made since 1927 go far to confirm the accuracy of Dr. Ball's theory.

Wind

The wind adhered closely to the prevailing directions, taken to coincide with the sand-dune axes in the various parts of the desert as shown on the map. The only appreciable variations were confined to short periods as follows: October 23–26, east and south-east wind between 'Uweinat and the Mourdi Depression; November 8–9, east-south-east wind at Camp 46.

No great strength of wind was encountered, though on many days it was strong enough to drive sand across country.

Temperature

Temperatures were taken daily whenever the aneroids were read, but no maximum and minimum thermometer was carried. It is unlikely however that either maximum or minimum varied appreciably from the temperatures taken about 1.30 p.m. daily and before sunrise. The highest temperature recorded was 99° F. at 2.30 p.m. on October 27 east of the Mourdi Depression, and the lowest was 48° F. on the morning of November 15 near Wadi Hussein. The weather became suddenly cooler from Camp 43 onwards, the date of the change being November 8. On our 1930 journey the same sudden change came on October 26.

Humidity

Sandford brought a whirling hygrometer with him and took a number of readings before sunrise and after midday. The following examples may be quoted:

			Relative humidity
October 28.	6.15 a.m.	Wadi Guroguro ..	51 per cent.
„	2.30 p.m.	„ ..	34
October 29.	6.30 a.m.	Wadi Hawa	59
„	2.15 p.m.	„	38
October 30.	6.30 a.m.	„	66
„	2.00 p.m.	„	38
October 31.	6.30 a.m.	„	67
„	2.30 p.m.	„	38
November 1.	6.30 a.m.	„	63
„	2.00 p.m.	„	31

From the above it appears that the percentage of humidity is approximately doubled during the night, the dry bulb ranging through about 35° F. (about 95° F. to 60° F.) between the hottest part of the day and dawn.

An interesting phenomenon was observed at 'Uweinat. The sky was overcast, especially on October 11 and 12, when there were heavy rain clouds. All the clouds seen in this area moved from the south-west, while the normal north-east ground wind blew steadily all the time, even at 6000 feet at the summit of 'Uweinat. During all the morning of October 12 rain was seen to be precipitated from the clouds into the dry ground wind below, where it was apparently re-evaporated.

APPENDIX V: TRANSPORT ARRANGEMENTS

R. A. Bagnold

A short description of our motor equipment may be of use to others who may be contemplating desert expeditions far away from bases where supplies and replacements can be obtained. The transport arrangements for all our past desert expeditions, evolving side by side with the evolution of American commercial vehicles suited more and more for desert work, have been designed to meet the following requirements: Personnel, food, water, etc., and essential equipment must be carried rapidly and without mishap as far as possible and as cheaply as possible across the most varied type of desert country without any supplies whatever being available *en route*.

Choice of car

The type of car must be suitable for the country to be traversed. If, for example, the country includes areas of very soft sand such as is found when crossing dunes, where any type of car, even with six wheels, is liable to get stuck, it is important that the car shall be light enough to be pushed out by the combined efforts of the party. If the country contains bad rock areas the chassis must be so flexible that the danger of its twisting so badly as to crack shall be reduced to a minimum. In country containing long stretches of soft sand, the car must have sufficient engine power to pull it through, and a sufficiently effective cooling system to prevent boiling.

The car must be reliable. This means that the make must be a sound one and the model used must have been proved by past experience to be suitable for the type of country to be traversed. The model should be at least in its second year, if not in its third, both for the above reason, and also to enable a sound estimate to be made of the faults which are likely to occur and of the spare parts which must be carried. The cars themselves must be new and not second-hand. The behaviour and idiosyncrasies of the cars must be well known to the members of the party who are going to drive and look after them. The design must be simple

so that replacements can be fitted and repairs made without trouble. The petrol and oil consumption must be low for the weight carried. This last requirement is another argument in favour of the light car rather than the lorry. We found that although a 30-cwt. lorry will carry twice as much petrol as a 15-cwt. car, its petrol consumption is more than double, so that its maximum range is less than that of the car. There is no doubt that at present, in the way of fulfilling all the above requirements, the Ford Model A car chassis stands by itself. I cannot see any advantage to be gained from the use of a six-wheeled car. With modern balloon tyres and some knowledge of sand running and of when to decrease the tyre pressure usefully, the four-wheeled Ford will tackle nearly all sand conditions successfully. The six-wheeler is complicated, heavy, and clumsy, and it uses more petrol for the load carried. The following remarks will therefore be based on the use of the Ford Model A chassis.

Carrying capacity and petrol consumption

Excluding a body weighing 550 lb. we find that this chassis will carry without risk of breakage a load of about 1750 lb. The petrol-consumption on the worst portions of the journey was 12 miles per gallon, and though the average mileage per gallon is about 14, I always work on the figure of 12 to allow for leakage and unforeseen troubles. Twelve miles per gallon, or roughly one 8-gallon case of petrol per 100 miles, is a safe figure for any type of desert country.

Number of cars and size of party

Our expeditions have never included native or other paid drivers. I think it is agreed that except in very unusual cases the performance of motor transport is reduced to a very small fraction of what is possible by employing drivers, native or European, who have no direct stake in the expedition and who are not sufficiently intelligent or interested to treat a car as it should be treated, with the same sympathy with which an English owner regards his hunter.

The ideal number of cars for a compromise to be struck between speed and absence of delays on the one hand and safety on the other is undoubtedly three. The ideal car crew consists of two people. But the actual number of cars will depend of course on the requirements of the expedition in personnel and stores to be carried.

Load and range of action away from supply base

The load consists of two parts: the "pay" load of passengers and their kit, spare parts, instruments, arms, etc., and the "supply" load of petrol, oil, water, and food. The pay load remains the same throughout the journey and is usually determined by outside considerations independent of distance and time. In our case this load amounted to 700 lb. per car, being composed of two men and their kits, spare parts, rifles and ammunition, theodolites, W/T receiver, cameras, maps, tools, spare tyre covers and tubes, and other oddments. The remaining 1050 lb. was available for the supply load. A typical supply load per car was as follows:

Petrol, 12½ cases (100 gallons), enough for 1200 miles	750 lb.
Oil, 2 gallons engine oil and 1 gallon gear oil	30
Water, 18 gallons, enough for two people in late summer, autumn, or winter for 15 days	180
Food, 90 lb., enough for two people for 15 days	90
	1050 lb.

At one time, by slightly overloading the cars, we set out with 110 gallons of petrol

per car, or a safe supply for 1320 miles. We could probably have done 1540 miles at our average of 14 miles per gallon.

By varying the conditions, *e.g.* supposing we only needed petrol for a journey of 800 miles, we could have carried food and water enough to enable us to stay out for twenty-seven days. One advantage of being able to travel thus self-contained for great distances is the saving in expense by avoiding the necessity of having to arrange for supply convoys, either car or camel, both of which cost a considerable amount when long distances are involved.

Packing and the design of the car body

To save weight the body of the car should be as small as possible. A large body, overhanging sideways, besides being heavy, causes unnecessary strain on the springs when the car lurches over at a steep angle while going over bad rocks or steep sand slopes. Careful packing is necessary so that there is no waste space and so that the stores are not damaged by undue movement inside the body. Petrol is supplied in Egypt, the Sudan, etc., in thin square 4-gallon tins, two of which are packed in a thin wood case of 8 gallons. Ideal packing is arranged by using these same wood cases as containers for all the other stores carried, and by building the car body so that its inside dimensions are an exact number of cases in width, length, and height.

The commercial type of "pick-up" body made of pressed steel is hardly suitable for a long expedition as there is insufficient space inside it. It is no lighter than a specially designed box-body of light wood which can be made abroad for £15 to £20.

It is important to provide as much easily accessible outside locker space as possible where tools, cameras, and other articles can be stored which are wanted in a hurry, or which are delicate, such as chronometers, aneroids, etc.

Alteration to the standard chassis

Very few are required. The most important is the addition of extra leaves to the rear spring. We use springs of twelve leaves in rear and the standard springs in front. The mistake is sometimes made of strengthening up the front spring with extra leaves. The result is that when one front wheel lifts over a large rock it is not the spring which gives but the chassis frame. With too strong a spring the chassis frame twists to such an extent that in time the front cross-member cracks in half. It is better to break a spring and replace it. With a strengthened rear spring the same thing happens; the rear cross-member ends by cracking, but here there is no alternative if heavy loads are to be carried.

The inevitable twisting of the chassis frame causes the top of the radiator to move sideways in relation to the scuttle of the car, to which it is attached rigidly by stay-rods. Again, something must give, and either the radiator is strained till its joints come apart or the stays are torn out of their sockets. Even the presence of the bonnet, we found, tends to strain the radiator by holding it too rigidly. By removing the bonnet altogether and also one or both of the tie-rods, no amount of rough going was able to damage the radiator.

It is a great help both when driving and when tending the engine, front axle, etc., if the front mudguards are discarded; though they are badly wanted for mud roads and when traversing sub-desert country where *heskanit* and other burrs abound. When the running-boards are used for carrying water tins their supporting brackets should be strengthened if the additional support given by the mudguards is removed.

Economy in radiator water was effected as described in my article in the *Geographical Journal* of July 1931, p. 13. The cars used practically no water during the entire journey.

Spare parts

The choice and number of spare parts carried is a matter of opinion. One can either carry everything which might break or wear out, or one can confine one's self to the few articles which are known to be required. We took the latter course. If a major unexpected part does break it is ten to one that it has not been included in the list of spares, even though the latter is so large as to overload the expedition. Apart from a few repair materials and small replacements, we only carried spare springs, two front and two rear, and spare front and rear cross-members complete with sets of bolts with which to replace the rivets one has to chip away to remove the broken members. Harding-Newman and I together replaced a rear cross-member in four hours. The only serious faults which occurred were the breakage of two front springs and two rear cross-members. One main engine support bracket cracked in two places, but I think that was due to a flaw in the material.

Carriage of water

This presents a difficulty. The container normally used in Egypt, etc., is an oblong steel box with soldered joints, holding 6–12 gallons. It is generally too heavy for the strength of its joints which are very liable to leak. With so large a single container an unnoticed leak will mean a serious loss of water. On this and previous expeditions we have used new 2-gallon petrol tins, replacing the leather washers by rubber ones to prevent the water becoming tainted. We found they lasted fairly well for a one-month's trip of 2000 miles, but after this the vibration starts them leaking along the bottom joints. They were carried in rows of six or seven tins along each running-board, held in place by a wood batten passing through their handles and secured to the running-board below by long bolts. For use, the water was drawn off by syphoning with a piece of rubber tubing in order to save dismantling the tins.

We have also tried soldering up water in ordinary light 4-gallon petrol tins and packing in the 8-gallon wood cases used for petrol. I think this is perhaps the best method of all. The water keeps fresh for long periods and it is quite easy to seal up the filling holes with a piece of tin and a soldering iron.

Tyres and their management

The necessity for running with soft flabby tyres when crossing areas of soft sand is well known to all who have driven for any length of time in sandy countries; but it is elsewhere so little realized that it may be as well to emphasize it here. Provided there are no rocks or large stones with which the tyres may come into collision, it is perfectly safe to deflate them till they are almost flat. The only risk is of the cover creeping round the rim and tearing the valve out of the tube. This is easily prevented by keeping the outer valve-retaining-nut very tight or by coating the rim with some tacky paint.

In rocky country however tyres will not last any distance before bursting if they are not kept thoroughly inflated, even at a higher pressure than the makers advise. If this is done covers will come to little harm even on the worst rocks. (Our experience has been with Firestone and Goodyear tyres.) The great difficulty is in mixed country containing both soft sand and rocks. Here avoidance of tyre trouble is really a matter of strength of mind. For one has to be continually deflating the tyres and pumping them up again. For this type of country a really good tyre pump is essential for each car. We used, in addition, two "Nev-a-Tire" mechanical pumps made by Messrs. Williams and James, of Gloucester. They were a great success and rarely got out of order.

The Goodyear Tyre Co. has lately introduced a super-balloon tyre or "air-wheel," of very low pressure. From a few trials in Egypt it looks like removing

even sand-dunes from the rapidly diminishing list of obstacles to desert motoring. It remains to be seen what effect collisions with rocks will have upon it.

Unsticking gear

The same methods were used as described in my previous paper (*Geogr. J.*, July 1931). I do not think that steel channels can be improved upon. We found a new use for them when our cars became bogged in the bottomless mud of the oases when we broke through the crust of salt pans while trying to cross them. Sloping excavations were made as usual in front of the rear wheels and the channels laid in them. But now the sledge hammer was brought into play to drive the channels well back under the wheels for 2 feet or more. The mud and crust on which the car was resting was now dug away, allowing the channels to take all the weight through the wheels. The car would by this means usually drive out under its own power.

Safety principles

The possible results of a shortage of water or petrol far out in the desert are obvious. The following Rules of the Desert have, I think, been adhered to consciously or unconsciously by all experienced users of motor transport when very long journeys are undertaken in unknown country. Perhaps it may not be out of place to state them here. (1) Enough care must be taken to obviate the risk of a total breakdown anywhere out of reach of help. (2) Petrol consumption must be estimated at the maximum rate over the worst type of country likely to be met with, and enough must be carried to enable the party to return to their base or reach other help if it is found impossible at any point to proceed farther. (3) No individual or single car must be left alone out of sight of an obvious unmistakable landmark. (4) The party must be confident at all times that they either know where they are, or have the means of finding out by astronomical observation. (5) Water is to be used for drinking only except at wells after the containers have been filled. A margin of 60 per cent. extra water should be carried over and above the estimated requirements. By rigid adherence to these few rules a party which includes skilled mechanics among its members should be able to undertake any desert journey with confidence.

APPENDIX VI: FOOD

V. F. Craig

Owing to our limited transport it was essential that the weight and bulk of our food supplies should be kept as low as possible. The scale per man per day was carefully worked out and is tabulated below:

Meat, 9 oz., or 4½ ozs. + 2 eggs.	Milk, 1½ oz.
Fruit, 4 oz.	Margarine, 1 oz.
Vegetables, 3 oz.	Tea, ¼ oz.
Potatoes, 2 oz.	Lime juice, $\frac{1}{16}$ bottle.
Onions, 1 oz.	Whisky, $\frac{1}{16}$ bottle.
Army biscuits, 4½ oz.	Sugar, 2 oz.
Fancy biscuits, 1 oz.	Marmalade, 2 oz.
Chocolate, 1 oz.	Flour, 2 oz.
Cheese, 1¼ oz.	Lard.

This scale could not reasonably have been reduced any lower.

The longest period to be catered for was that of forty-two days between Cairo and El Fasher, during which we could not rely on obtaining anything from the country *en route*. The reserve allowance for this period was an additional seven

days' food. We had four meals on a normal day: Breakfast at 6.30 consisted of eggs or tinned fish or sausage. At 11 a.m. we halted for chocolate and biscuits. Lunch, cold, consisting of tinned fruit, cheese, jam, and biscuits, was usually at 1.30. Dinner at about 7 p.m. contained meat and vegetable, usually as a stew. The food required on a long motor expedition of this sort is very different from the simple fare to which the camel traveller is accustomed. Owing to the violent physical exercise continually demanded in extracting cars from soft sand by digging and pushing, and in man-handling stores, etc., and to the mental exertion of driving a car all day over a continuous hazard or of high-speed navigation, a full and varied diet is very necessary. Although we had to be content with little but tinned food, the quality and variety which is available nowadays is remarkable.

Our diet was naturally influenced by the weather, which at the beginning of the journey was hot. It remained so throughout the outward journey to El Fasher and until November 8 on the return, after which it was definitely cool. During the cool period there was a noticeable demand for more of everything, and meat was wanted in the middle of the day instead of tinned fruit.

The normal water ration during the early hot period was 5 pints. This was consumed as follows: 1 pint as tea for breakfast, 1 pint with lime juice for lunch, and 1 pint in waterbottles to be drunk as individuals liked. The remaining 2 pints were drunk after arrival in camp, one as tea and one with whisky.

The fuel for cooking consisted of empty petrol cases. These provided far more wood than we actually wanted. Fire pots were made from empty 4-gallon petrol tins by cutting off the top and making a large hole in one side for stoking. Round cooking-pots were chosen which could be lowered into the square tins and were supported by the handles resting on the edge of the tin, leaving 6 inches of space below for the fire. All the cooking gear could thus be packed in a wood petrol case. Cooking by this means we found to be far more rapid and effective than by the use of Primus stoves, which are not suitable for use in the open air or in sandy country.

APPENDIX VII: COST

R. A. BAGNOLD

Statement of Expenditure and Income

1. TRANSPORT A/C

Expenditure		
Four Model A Ford car chassis	£E.532.000	
Four specially designed bodies	110.500	
Tyres and tubes	97.220	
Tools, spares, and garage work	89.064	
Special radiators (found unsuitable and not used)	14.521	
Registration and insurance of cars	41.340	
Miscellaneous	12.435	
		£E.897.080
Rebates		
Spares and tyres returned after expedition ..	41.917	
Sale of cars	237.500	
		279.417
Net expenditure		617 663

2. PETROL A/C

Expenditure

Petrol for running cars	2.080	
Petrol at Cairo, Kharga, Selima, and Fasher—total 1712 gallons	191.660	
Oil, ditto, total 36 gallons	9.715	
Transport Halfa to Selima, etc.	25.360	
Containers, etc.	6.000	
		234.815
Rebates		
Supplies returned afterwards, etc.		4.105
Net expenditure		230.710

3. FOOD A/C

Expenditure	82.538
Rebate. Sale of surplus food	3.750
Net expenditure	78.788

4. SURVEY A/C

Expenditure

W/T time signal set, batteries, valves, etc. ..	13.725	
Insurance of instruments	6.811	
Maps, duplicating, etc.	8.353	
Overhaul of chronometers	2.037	
		30.926

5. MISCELLANEOUS A/C

Transport of stores to Egypt, etc.	6.505	
Postage, telegrams and cables, clerical work, duplicating, etc.	11.044	
Miscellaneous purchases	9.774	
		27.323

6. TOTAL EXPENDITURE FROM 1–5

Transport	617.663	
Petrol	230.710	
Food	78.788	
Survey	30.926	
Miscellaneous	27.323	
		985.410

7. INCOME

From Royal Geographical Society	194.500	
From Oriental Institute	200.000	
From members of expedition (divided equally between eight) 73.864 each	590.910	
		985.410

(NOTE.—0·975 Egyptian Pounds are equivalent to One Pound Sterling approx.)

NOTE ON A MAP OF THE TURFAN BASIN

SIR AUREL STEIN, K.C.I.E., F.B.A.

THE map discussed in this note is intended to record the surveys carried out, mainly in the course of my third Central-Asian expedition, within that remarkable drainageless basin which lies between the southern slopes of the eastern Tien Shan and the desert ranges of the Chöl-tagh. Special geographical interest attaches to this basin, conveniently designated by the modern name of its chief oasis, Turfan, not only because it contains the deepest depression below sea-level in the whole of Asia apart from the Dead Sea, but also on account of its characteristic physical features. These exactly reproduce, as it were, on a small scale those of the Tarim basin, the greatest drainageless area of innermost Asia.

A variety of causes, largely geographical in origin, have invested the Turfan depression with considerable political and cultural importance during early periods of Central-Asian history. This importance is reflected by the large number of ancient remains which are to be found there within a comparatively small area and which the great aridity of the local climate has allowed to survive above ground.

The archaeological interest presented by those remains and the labours claimed by their survey and partial exploration caused me on my third Central-Asian expedition to spend over three months of the winter of 1914–15 within the Turfan basin. Busy as I was kept by antiquarian labours I endeavoured to utilize this stay also for observations on those geographical features which give a strongly distinctive character to the Turfan district and especially to its inhabited portion. For this purpose a more detailed survey of its topography was essential than that which it had been possible to effect on the occasion of my first visit to this area in November 1907. At that time Rai Bahadur Lal Singh, Extra Assistant Superintendent, Survey of India, my devoted old travel companion, had carried a reconnaissance survey on the quarter-inch scale along the main routes of the area.

I accordingly arranged for a plane-table survey on the comparatively large scale of one inch to the mile to be extended by the late Surveyor Muhammad Yaqub Khan, who had been deputed by the Survey of India as my second topographical assistant, over as much of the central portion of the basin as limitations of time would permit. The cultivated areas of the district are with very few exceptions confined to this portion, and the ruins of pre-Muhammadan times are almost all to be found either within them or in their close vicinity. This circumstance made it possible for me in the course of my successive visits to the different ancient sites to keep within easy reach of the young surveyor and thus to exercise personally that measure of supervision and control which previous experience of his abilities had rendered advisable.

A special map of the Turfan basin on the scale of 1 : 250,000 has been prepared at the Geodetic Branch of the Survey of India, Dehra Dun, in order to provide the geographical and antiquarian student of this interesting ground with a cartographical representation of its topography on a larger scale than that of the 'Maps of Chinese Turkistan and Kansu' (1 : 500,000) attached as

Vol. IV to my 'Innermost Asia,' and also separately issued by the Survey of India in 1923 with a "Memoir" from my pen forming Vol. XVII of the *Records of the Survey of India*. It is from this map that, with the kind permission of the Surveyor-General of India, the map accompanying this paper has been reproduced on a reduced scale.

In addition to the above detailed material the map embodies the plane-table work which was carried out by R. B. Lal Singh in 1907 and 1914–15 to the north and south, respectively, of that central belt of the basin as well as some minor plane-table traverses in the north-west and south-east portions of the sheet from Khan Sahib Afraz Gul's routes. The representation of physical details is the same as is adopted in my 'Maps of Chinese Turkistan and Kansu' and fully explained in my "Memoir" on them.[1] The same applies also to the use of symbols and the record of local names.[2]

The area represented in the map falls within Sheets No. 28 and No. 31 of the 'Maps of Chinese Turkistan and Kansu,' and the identical values for observed longitudes and latitudes as recorded in the corresponding "Notes" of Chapter IV of my "Memoir" have been used throughout for the adjustment of the plane-table work.[3] Since the Turfan basin derives special interest from the great depth below sea-level to which it descends in its lowest portion, care had been taken to obtain observations with a mercurial barometer in a comparatively large number of places. The heights or depressions derived from these observations have been recorded in the "Notes" of the "Memoir."[4]

All the other heights entered were deduced from observations with aneroids corrected to accord with the mercurial readings at the places where these also were available. It deserves to be mentioned that the results from the aneroid readings had proved very satisfactory throughout my third expedition, as shown by Dr. De Graaff Hunter's remarks on them.[5] The clinometrical heights shown are based on aneroid readings observed at the points nearest to the plane-table stations from which the former were taken. The results from the numerous observations with the hypsometer, on which Surveyor Muhammad Yaqub mainly relied in the course of his work within the area below sea-level, have unfortunately proved untrustworthy and had hence to be discarded. This accounts for the largely conjectural character of the approximate datum line and contours below sea-level indicated in the map.

From the above record of the materials used in the compilation of the map I may now proceed to a brief description of the chief physical features which the area represented in it exhibits. In respect of this analysis, summary as it must be for various reasons, I may at once acknowledge some serious limitations. In the first place I ought to point out that my want of geological training, combined with my equally regretted ignorance of Russian, restricts my knowledge

[1] See *Records of the Survey of India*, vol. xvii, "Memoir on Maps of Turkistan and Kansu," pp. 57 *sq.*

[2] Cf. *ibid.*, pp. 59 *sqq.*

[3] See *ibid.*, pp. 83 *sq.*

[4] Regarding the methods of reduction applied to readings both by mercurial barometer and aneroids, see Dr. J. De Graaff Hunter's Appendix B, "Memoir on Maps," etc., pp. 152 *sqq.*

[5] See "Memoir," Appendix B, p. 151.

as regards the most remarkable physical feature of the Turfan basin, its great depth below sea-level, to what information I can gather from the brief abstract Professor Suess's great classic, 'The Face of the Earth,' gives of the accounts contained in the publications of several distinguished Russian geologists.[1] The same applies also to the formation of the very striking hill chain which overlooks that great fault-trough from the north, and with its much disturbed deposits of sandstones and conglomerates represents the upthrown fault-ridge of this mighty dislocation.

It is at the foot of this hill chain, so utterly barren and forbidding with its red glow as to account for its Chinese name of "Hills of Fire," that the depression receives that supply of water which is utilized for irrigation to the utmost and alone renders cultivation possible. Most of the irrigation thus secured depends not upon the surface flow from springs but upon an elaborate system of *karezes* or underground wells and canals which tap subterranean drainage. This system is nowhere else practised in Chinese Central Asia and is believed locally to be of comparatively recent introduction from distant Persia. A close examination of it seems essential for a proper estimate of the economic resources of the Turfan district.

An exact comparison of the cultivated area now dependent on karezes with that irrigated from spring-fed streams might well throw light on the much-discussed question of climatic change; for archaeological evidence distinctly suggests that the economic importance of Turfan was quite as great, if not greater, during ancient and early mediaeval times, when we must assume that its oases depended wholly on irrigation from surface drainage. Yet, interesting as the question thus raised must be for the geographical student and the antiquarian also, it was not possible for me to spare time for the collection of adequate data regarding those different sources of irrigation used in the scattered oases of Turfan.

It would have been of distinct interest also from more than one point of view if it had been practicable to collect reliable data as to the population in the oases, large and small, comprised within the cultivable belt. But it was not possible for me to secure access to official statistics, supposing that such were to be found in the Chinese magistrates' Yamêns. What figures as to the number of households I was able to obtain by local inquiries at certain of the oases can scarcely be taken for more than rough traditional estimates indicating their relative importance. Yet even in this respect more reliable guidance may probably be gained from the extent of land actually under cultivation as the map's record based on the detailed survey shows it.

As already mentioned above, we find most of the physical features which divide the Tarim basin into well-marked different zones reproduced also in the Turfan basin, though on a much smaller scale. A determining factor affecting all those zones is the aridity of the climate, and this is equally great in both basins. To it is due the fact that in the Turfan basin, just as in its much larger counterpart westwards, settled existence implying cultivation is entirely dependent on irrigation and on what water is supplied for it by the mountains.

[1] Cf. Suess, 'The Face of the Earth,' translated under the direction of Professor W. J. Sollas, iii, pp. 166 *sqq*. Full references will be found there to the accounts of the brothers Grum-Grimailo, Bogdanovich, Obrucheff, Roborovski, etc.

In the case of the Tarim basin two great snowy ranges, glacier-crowned in many parts, the Kunlun in the south and the Tien Shan in the north, feed rivers which carry considerable volumes of water over their alluvial fans and allow large compact oases to be maintained there. The Turfan basin too is enclosed by two ranges stretching along its longitudinal axis. But the southern one rises nowhere to heights which could retain snow and is throughout so defective of moisture as fully to deserve its local designation of *Chöl-tagh*, the "Desert Hills." Water, usually brackish, can be found there only in rare wells or natural cisterns. Only on exceptional occasions may flood water descend in some gorges of this barren range to lose itself in the salt-encrusted marsh-bed of the Aidin-köl which stretches along its northern foot and forms the lowest part of the depression.

It is due solely to the vicinity of the Tien Shan main range stretching north of the basin that Turfan owes its oases and its economic importance attested all through historical times. That portion of the main range which sends its drainage southwards into the Turfan basin rises, as the map shows, to peaks over 14,000 feet. It attains over most of its length a crest-line which cannot fall much short of 11,000 feet and to the west is certainly higher. There it carries permanent snow-beds for a distance which from the observations made on our crossing of the Pa-no-p'a pass may be estimated as at least 50 miles. The conditions there noted on 23 October 1914 indicated an approximate level of about 12,500 feet for the snow-line. Its comparative lowness is largely accounted for by the fact that a far moister climate prevails on the northern slopes of the Tien Shan. This is abundantly attested by the fact that ample conifer growth is to be found there from an elevation of about 6500 feet upwards, while along the northern foot of the range cultivation is possible with the sole help of rain- and snow-fall right down to elevations between 2000 and 3000 feet.

The rich quasi-alpine vegetation to be met on the northern slopes of the range makes the contrast of the stony barrenness to the south of the crest-line all the more striking for the traveller. There only the scantiest grazing is to be found even at the very heads of the valleys. Farther down scrub and occasional growth of willows and wild poplars are closely confined to the banks of the small streams which descend here between spurs of utterly bare rock and conglomerate. These streams carry a considerably increased volume of water during the spring melting of the snow-beds on the crest of the range and on the rare occasions when heavy rain clouds pass across it from the north. But nowhere does their water succeed on the surface in crossing the zone of utterly bare piedmont gravel. This, from 20 to 25 miles wide on the average, everywhere separates the foothills of sandstone or conglomerate from the nearest areas of cultivation.

Whatever water is brought down by those streams is quickly absorbed by those huge beds of detritus or else evaporates under the fierce sun of the spring and summer of the Turfan basin. Springs are to be met only at certain points of the dry flood-beds which traverse this huge gravel glacis. These beds are clear marks left behind by the far more abundant drainage of periods when climatic conditions were moister. Near those springs small patches of vegetation, such as the map shows at Shaftulluk, Chichan, Örtang-aghzi, usually

including some orchards and arbours, serve as much-needed halting-places for travellers and traders who proceed from the Turfan oases to the passes of Pa-no-p'a, Sardakdawan, and Qara-dawan.

These passes give direct access across the Tien Shan to the fertile tracts around Guchen in the north. They are all open to traffic with horses for the greater part of the year, while the more devious but easier routes to the east and west by the saddles of Ta-fan-ch'êng and Ku-ch'üan are available for cart and camel transport at all seasons. This fact largely accounts for the close economic relation which exists between the districts of Turfan and Guchen, notwithstanding the intervening mountain range. It is also duly reflected by their close political connection throughout earlier historical periods.[1]

Before proceeding to visit the series of minor oases which are met after descending that wide gravel glacis, we may acquaint ourselves rapidly with that very striking feature of the Turfan basin, the rugged hill range which forms the northern rim of the great fault-trough. It is the result of geological flexing and fracturing which has produced the basin. It has upheaved and greatly disturbed "not only the coal-bearing clays and variegated sandstones of the Angara series, but also the red conglomerates and friable sandstones of the Gobi series."[2] As shown by the map, this hill range, known over different sections by varying local names such as Tuz-tagh or Kawan-tagh, stretches with a general east-to-west direction along the whole length of the depression from the Pichan oasis to north of Toksun.

It is to the east of its middle portion marked approximately by the gorges of Sengim and Toyuk that it attains its greatest height, rising in rugged ridges to approximate elevations between 2200 and 2700 feet. The slopes throughout show the effects of excessive erosion by water action, as seen in photographs taken near the Toyuk gorge.[3] Except at the bottom of the gorges in which small streams gathering from springs at the foot of the gravel glacis have cut their way through the range, these hills are absolutely bare of vegetation. Their reddish colour and fantastically fissured slopes add still further to their forbidding appearance.

Masses of drift sand are found in some places heaped up on the north slopes, as near Murtuk.[4] Near its eastern extremity the range merges in an area of huge ridges of dunes, appropriately known as *Kum-tagh*, "The Sand Mountains." These have been rightly assumed to overlie the eastern continuation of the fault-trough towards Hami. On the south they are adjoined by the waterless wastes of the Chöl-tagh.

There can be little doubt that the drift-sand ridges of the Kum-tagh owe their position in the south-east of the Turfan basin to the effect of "aspiration." The violent north-west winds which sweep over the basin during the spring and summer are obviously due to the cold air of the mountains and of Dzungaria being drawn into the Turfan basin by the fierce summer heat which

[1] Regarding the economic intercourse and common political fate of the two territories (known to the Chinese Annals as Cismontane and Transmontane *Chû-shih*), as a result of geographical factors, cf. 'Innermost Asia,' ii, pp. 569 *sqq.*

[2] See Suess, 'The Face of the Earth,' trans. Sollas, p. 166.

[3] See "Memoir on Maps," Fig. 29, B; 'Innermost Asia,' ii, Figs. 309, 311.

[4] See 'Innermost Asia,' ii, Figs. 314, 315.

prevails in the depression and causes the hot air to rise there. This heat itself directly results from so great a portion of the basin lying deep below sea-level.

It is equally clear that those winds, ever since the great fault-trough was formed, must have been constantly at work deflating the slopes of the mountains and the glacis below them, both wholly unprotected by vegetation. The fine drift sand thus eroded is bound to be carried to the south-eastern extremity of the depression and to find its place of deposit where the effect of that "aspiration" is countered and neutralized by the air current from the cooler heights of the Chöl-tagh and the great Pei-shan plateaus eastwards.

That wind erosion actually asserts itself in places also within the cultivated area I had occasion to observe in the north-western portion of the Turfan oasis. This, as the map shows, occupies a gap about 5 miles wide in the hill chain fringing the fault-trough. It may be described as marked on the east by the bed of the stream which issues from the valley of Buluyuk and on the west by the two deep-cut ravines of the 'Yar' which enclose the island-like site of the ancient Turfan capital of *Chiao-ho*, now known as Yar-khoto. There to the east of the Yar in close vicinity to cultivation I noticed patches of ground overrun by small dunes. The inroad of fine sand driven by the ***burans*** from the north-west threatens the fields in the vicinity, and in order to protect them from the risk of attending wind erosion their surface is covered with clods of hard clay before the windy spring season sets in. The intrinsically fertile fine sand, or rather dust, which is deposited between the clods is considered on such ground an adequate substitute for manuring.

Owing to the position of the tract of Turfan proper in the gap above mentioned the physical features affecting cultivation are there less clearly defined than in the smaller oases which are found along the northern foot of the hill chain overlooking the fault-trough. Throughout the string of these oases, from Buluyuk in the west to Pichan in the east, the water supply needed for irrigation is primarily derived from springs rising in close vicinity of the cultivated area either within flood-beds or else on their alluvial fans. It is obvious that the rise of these springs is due to drainage from the mountains having been absorbed higher up by the gravel-beds of the glacis and being here forced to the surface on striking impermeable strata of the fault-ridge. The supply of these springs is in the several oases supplemented to a varying extent by that of karezes. These tap the subterranean drainage farther away from the flood-beds and allow water to be brought to portions of the ground which irrigation channels taking off direct from the springs would not command.

As the construction of karezes involves very heavy expense the provision of irrigation by this means must necessarily depend on the extent and quality of the arable land within convenient reach of the karez mouths. This explains why, *e.g.* in Pichan, reckoned at 2000 households, the water from springs suffices to irrigate twice as much land as that derived from karezes, while Khando, the oasis nearest to the west, with its 500 households, is almost wholly dependent on karezes. Conditions closely resembling those of Khando are found also at Sengim, whereas at Murtuk, where the use of its spring-fed stream provided for a settlement of about 300 households previous to the Chinese reconquest of the Province, the construction of 28 karezes is believed

to have added 200 more. At Lamjin, reckoned at about 400 households, spring-fed streams and karezes may be supposed to account for about one-half each of the irrigated area.

The assured supply of water which both springs and karezes provide throughout the seasons, coupled with the warmth of the climate during eight or nine months of the year, make it possible in these oases, as in all the others of the basin, to reap two annual harvests. In all kinds of cereals, as well as in fruits and in cotton, the produce of cultivation in the Turfan oases is plentiful. The exceptional fertility of the soil when irrigated under such favourable climatic conditions and the profit derived from such a valuable and easily exported produce as cotton sufficiently explain the use of the karez system notwithstanding the heavy expenditure of money and labour it involves.

At the same time, as a consequence of the great extent of the profitable cotton cultivation for export to Dzungaria and beyond, and owing also to the presence of a considerable trading population in the large southern oases, Turfan is obliged to supplement its foodstuffs by imports from the north. On the other hand, the absence of grazing both in the mountains and in the depression makes Turfan depend on the tracts across the Tien Shan for livestock and wool. The economic interdependence thus created by diversity of geographical conditions is reflected throughout the political history of those territories.[1]

The agricultural conditions just described apply equally to the much larger oases to the south of the hill chain, but with a difference as regards that portion of irrigation which is not derived from karezes. Practically nowhere do we meet with springs along the southern foot of those utterly barren hills; but instead, as a look at the map shows, we find a number of streams breaking through that range and carrying a surface supply of water to parts of the potentially fertile belt of ground which forms its glacis. Those streams receive all the water of the springs and karezes which is left after having served the needs of the northern oases and bring it in deep-cut narrow gorges to where these debouch. The fertile loess-like ground which slopes down from the foot of the range permits the water of the streams to be utilized for irrigation within comparatively short distances from the mouth of the gorges and thus saves it from being lost through evaporation before it could be turned to use.

Thus we find the position of the three large and compact oases of Lukchun, Qara-khoja, and Turfan directly determined by the points at which the streams from the gorges below Lamjin, Murtuk-Sengim, and Buluyuk debouch into the depression. An examination of the map affords interesting evidence as to the close correspondence between the areas of cultivation in those oases and the observed volumes of water in the streams which feed their canals.[2]

[1] Cf. 'Innermost Asia,' ii, pp. 568 *sqq.*, regarding this interdependence.

[2] Measurements taken on different dates of November 1914 showed volumes of 125 cubic feet per second in the stream coming from Lamjin which irrigates the important oasis of Lukchun, and of 120 cubic feet per second at Sengim-aghiz. There the stream from Murtuk and Sengim debouches, and there the canals irrigating the fields of Qara-khoja, around the large ruined town of ancient *Kao-ch'ang*, have their heads. I regret not to have had an occasion to measure the volume of the stream of Buluyuk at its debouch. But lower down, where it is crossed by the road from Qara-khoja, it still

Reference to the map is equally instructive also as regards the great extent to which cultivation in those main oases is nowadays supported by irrigation from karezes. The absence of statistical data, such as only proper revenue records could supply, makes this cartographical evidence particularly useful. At none of those oases is it more striking than at the extensive area used mainly for the cultivation of cotton which stretches to the north-west and south-east of the town of Turfan, the modern administrative and trade centre of the territory. Here we have a continuous series of karezes, more numerous than limitations of scale would permit to be individually shown on the map. They tap the subterranean drainage both at the foot of the gravel glacis which stretches down from Shaftulluk towards the previously mentioned gap, and also along the foot of the hill range east of Buluyuk. The utter barrenness of this range and the extreme rarity of occasions when it receives any rainfall, suggest that the subsoil water which the wells at the heads of the karezes strike may also be derived from the precipitation which the snowy heights of the Tien Shan regularly receive. But only competent geological investigation could prove whether such an assumption is compatible with the character of the strata likely to underlie that fault-ridge.

It is obvious that the comparatively gentle declivity which marks the northern side of the subsidence facilitates the use of the subterranean water supply over a broad belt of ground. This helps to explain why we find the map marking an almost continuous string of detached cultivation plots, usually small, extending below the main oases from the south-west of Turfan to the south-east of Lukchun. All of them depend solely on karezes, and the construction of new ones, though often a speculative undertaking, is still proceeding.

As already stated, the construction of a karez involves heavy outlay; for the number of successive shafts to be sunk while cutting the subterranean channel amounts sometimes to two hundred or more. Figures up to 10,000 taels of silver were named to me as having been spent over certain karezes. It is obvious that the extension of karez cultivation must be determined not merely by the configuration of the ground, which may or may not permit the water-carrying stratum to be struck at a "paying" depth, but equally also by the quality of the soil on the ground to which the discharge of the karez can be brought. This observation may help to explain a certain inequality shown by the map in the distribution of those detached karez-irrigated plots. Whereas in the vicinity of Turfan proper these plots keep within a comparatively short distance of the foot of the hill chain, they are found to extend much farther away from it to the south below Qara-khoja and Lukchun.

I believe that a likely explanation is to be found in the greater salinity of the soil as we proceed westwards in that portion of the trough which lies below the approximate level of 500 feet below sea-level. The increased appearance of a soft salt-crust covering the ground, as observed on the route from below

carried on 8 February 1915 a volume of 52 cubic feet per second, and several canals take off from it higher up.

On the other hand it is interesting to note that the water of the stream which descends the rugged gorge of Toyuk and the volume of which below Subashi measured 45 cubic feet per second on 17 November 1914, suffices only for the limited cultivation of Toyuk and Yankhe, notwithstanding the very careful use made of it for the famous vineyards of the former place.

Faka-bulak towards Bejan-tura, is certainly due to this area forming the terminal delta of the river which descends past Toksun into the deepest part of the trough marked by the Aidin-köl marsh. It is the latter's main feeder; but, as the shrunk size of the marsh shows, much of the flood water brought down by the Toksun river from the high Algoi valley in the west is lost before reaching the Aidin-köl, through inundation of the deltaic ground. Evaporation then causes the soil there to become impregnated with salt.

A notable contrast to this is presented by the ground to the north of the Aidin-köl and to the east of it. To the north we find the large karez-irrigated oasis of Chige-bulak approaching within a few miles the shore of the ancient dried-up lake-bed of which the Aidin-köl is a remnant. Then, farther away to the east, there is similarly below Lukchun and towards Deghar karez cultivation to be seen at no great distance from that dried-up lake-bed. On my visit to the ruined site of Chong-hassar, only about 2 miles from the shore of the hard salt-encrusted bed, I found the scrub-covered loess-like ground still capable of cultivation if it were possible now to provide for its irrigation.

Here I may conveniently mention that the oasis of Toksun, which through unavoidable circumstances remained outside the detailed survey of 1914–15, presents the same features of cultivation as noted above in the case of oases like Qara-khoja and Lukchun. While irrigation supplied by the river apparently accounts for the major part of the cultivated area, the presence of karezes on both sides of the river-bed is also noted. Toksun, at a depression of 140 feet below sea-level, shares the climatic conditions of the other oases within the Turfan trough.

Before leaving that zone of the Turfan basin to which permanent human occupation has been confined all through historical times up to the present, I may aptly quote here from 'Innermost Asia' an observation concerning it which has a wider geographical bearing: "The development of Karez irrigation in the Turfan area is of comparatively recent date, and its introduction does not reach back farther than the eighteenth century.[1] But that the district possessed a dense population, wealth and corresponding economic importance in much earlier periods also, is abundantly proved by the large number, size, and elaborate character of its ruins as well as by its recorded history. Irrigation must have been all through historical times indispensable to cultivation within the Turfan area. We are therefore driven to the conclusion that the water supply brought down in streams from the mountains was more plentiful in ancient times than it is now, when subterranean drainage has to be tapped by Karezes in order to supplement it in a proportion which at present is probably close on one-half of the total available supply." The bearing of this conclusion upon the question of desiccation in Central Asia, whether local or general, is clear.

[1] Regarding the karez cultivation of Turfan and its introduction, cf. the remarks of Professor E. Huntington, based on careful observation, 'Pulse of Asia,' pp. 310 *sqq.*

The total absence in Chinese historical notices relating to Turfan of any reference to so striking a feature as the use of karezes may safely be considered clear evidence that this method of cultivation was not known there down to T'ang times and even later. It is very difficult to believe that the detailed and exact description of the territory of Kao-ch'ang in the *T'ang shu*, which duly mentions the two annual crops and the cultivation of cotton there, could have passed over the karez system if it had then existed.

There still remains to be noticed that deepest portion of the Turfan depression which forms the terminal basin of whatever surface drainage is to be found in it. My remarks on it must be brief; for, as plentiful archaeological labours, to my regret, did not allow me to devote myself personally to its study, I have little to add to what the map clearly shows. I had however taken special care to entrust the survey of the dried-up lake-bed which forms the most characteristic feature of this area to R. B. Lal Singh, and to secure through this ever-careful and painstaking topographical assistant a series of reliable mercurial barometer observations along its shore.

They extend from the eastern extremity of the salt-encrusted dry bed at the point known as *Tuz-kan*, the "Salt Pit," to the ruined watch-tower of Bejan-tura, the "Tower of the lifeless (ground)."[1] Examination of the readings thus observed leaves little doubt that the greatest depth of −980 feet recorded on the actual surface of the bed about 3 miles to the north-west of Tuz-kan represents as close an approach to the maximum of the subsidence as could be obtained without exact levelling operations. In their absence it cannot be considered as certain whether the Aidin-köl salt marsh, which at the time of the survey, 18–21 January 1915, was seen to hold water, marks the deepest portion of the bed. It is obviously the one which is most likely to be reached by flood water from the Toksun river. But evaporation and the presence of ridges of hummocky hard salt such as I observed rising above the flat expanse of crumpled-up salt cakes on a short reconnaissance made east of Bejan-tura, may well keep such water from spreading farther eastwards.

In this, as in other respects also, this terminal depression of the Turfan trough, having a total length of some 30 miles, presents a striking pendant to the dried-up salt sea-bed of the Lop Desert,[2] though on a much reduced scale. Here too the southern shore of the salt-encrusted bed is overlooked by a steadily rising glacis of coarse gravel and detritus, utterly devoid of vegetation, leading up to the foot of the northernmost range of the Chöl-tagh. The rise of the ground adjoining the northern shore is far more gentle, and here subsoil moisture derived from the irrigated areas farther north permits of the growth of low scrub, reeds, and tamarisks. It is dreary arid ground, yet not as forbiddingly bare as the slopes of the Chöl-tagh to the south of the dried-up lake-bed.

Up those slopes, covered with stony detritus and in parts also with accumulations of drift-sand, there lead tracks crossing the rocky wastes of plateaux and much decayed ranges towards the Lop region in the extreme east of the Tarim basin. Those ranges all belong to a system appropriately designated as the *Kuruk-tagh*, the "Dry Mountains." Of them the one crossed by the passes of At-ölgan-dawan and Igar-dawan at elevations of about 4000 feet above sea-level forms the watershed towards the Turfan basin. Nowhere between that watershed and the bottom part of the trough can drinkable water be found, except to the west, where the ancient highway from Toksun towards Qara-

[1] It is probably from a careless pronunciation of this name, inadequately recorded, that Russian maps and other publications have derived the apocryphical name "Bujento," not known locally as a designation of the marsh.

[2] For observations on the characteristic features of the dried-up bed of the ancient Lop Sea, cf. 'Innermost Asia,' i, pp. 295 *sqq.*

shahr and the north-eastern corner of the Tarim basin crosses a higher portion of the range.

The rapidly rising ground to the west of Toksun, with the great valley of Algoi and those descending from the side of Urumchi, has remained outside our surveys. Nor have I had an opportunity of becoming personally acquainted with that portion of the depression which may be assumed to extend due east of the Kum-tagh towards Hami. So here I may close this summary account of a well-defined Central-Asian region which, small as it is in extent, can yet lay claim to special geographical interest as illustrating all physical features that are typical of innermost Asia.

Note by the Editor:

When Sir Aurel Stein consented some two years ago to write for the *Journal* a note on his Map of the Turfan Basin, it was at first contemplated that we should ask the Surveyor-General of India to print for us an edition of the "Map showing the main portions of the Turfan Basin" which had been drawn on the scale of 1/250,000 under his direction at the Trigonometrical Survey Office, Dehra Dun, and is included among the special maps published by the Survey of India. But further consideration showed that not only was this sheet inconveniently large for the *Journal*, but the complexity of its names and detail, and the emphasis given by colour to the cultivated areas, had inevitably obscured to some extent the remarkable topography of the basin. With the consent, therefore, of Sir Aurel Stein and of the Surveyor-General, we have extracted the topography from the larger sheet, and have emphasized the relief by adding a simple layer-colouring. The resulting map, on half the scale of the original, must be considered as a supplement to the latter, made for a special purpose; for a full appreciation of the above paper the student will necessarily refer to the map published by the Survey of India.

THE PUSHT-I-KUH

FREYA STARK

I HAD attempted in the autumn of 1931 to reach the middle of Luristan, the country of Tarhan east of the Saidmarreh river, where the old civilization whose tombs have already given so rich and mysterious a harvest of bronzes during the last three years is said by the tribesmen to have its centre. I was prevented from reaching the river, less by the danger of the country than by the solicitude of the Persian police. I decided last September on a second attempt, trying this time to make due east from 'Iraq across the barrier of the Pusht-i-Kuh and thence across the Saidmarreh to Tarhan. This time I succeeded in reaching the river and gazed "upon a peak in Darien," in other words, the lands of Tarhan beyond; but here again the Persian police, who had been pursuing the rumour of me for some days on horseback over rough country, came up with me and politely but inexorably discouraged further progress. They took me to the small capital of the region, where workmen imported from Kermanshah are now building houses in a land hitherto entirely nomadic. After a friendly detention, I was escorted four days' ride across the north of the province back to the 'Iraq border. Although I thus achieved no more than a bird's-eye view of the land I was particularly interested in, I was able to examine Pusht-i-Kuh with some thoroughness during my three weeks of wandering, and to map out roughly the eastern side of the great range of Kabir Kuh which divides it, and has not yet been surveyed.

Leaving Baghdad by car on September 10, I drove by Kut el Amara to Badrah on the frontier, after obtaining a visa for Persia which left the exact place of entry purposely vague. My guide was an old quilt-maker whose only qualification was that he belonged to the country and people, and that he carried about with him an air of holiness which he supported by frequent and inconvenient prayers. How he got his passport I do not know, nor did I inquire. It was produced, together with two mules and muleteers, after three days of dreary waiting and many secret conversations in a house among palm groves at Badrah. Though still in 'Iraq, we were already among Persians. Our little village, enclosed in a mud wall, belonged to the family of the Vali of Pusht-i-Kuh, and now in the date season stood a nightly unobtrusive siege from marauding Arabs, who were kept off by occasional rifle shots as they climbed the palms in the moonlight. I was glad enough to leave it, and to ride across a strip of desert towards the hills and the Kunjan Cham river, which is the border.

Our two muleteers, with nothing said, took it for granted that we would not be anxious to see more policemen than necessary. They led us along the sunken river-bed among tamarisk bushes, going quickly and silently and keeping just out of sight of both Zurbatiyah, the Persian frontier town in the distance, and of Do Ab, the police post on the bank just above us, until we emerged in Persia at a small camp to which the two men belonged, where, they said, "our kinsmen will not talk." These people already belonged to the Lurs of the Pusht-i-Kuh and were living not in tents, but in their typical summer huts—a framework of poles roofed with oak branches on which the dead leaves remain to form a

shelter against the sun. A screen of reeds woven with black wool into patterns makes the walls. The fact that there was no camel saddle to sit against showed that we were out of the realm of the Badawin and among the people of the hills.

Political circumstances make the entry of Pusht-i-Kuh from 'Iraq a more delicate affair than it would be otherwise. The ex-Vali, who used to be the despot of this country and was always friendly to the British, lives in 'Iraq in exile with several of his sons. There is constant intercourse and intrigue between his followers and the hillmen, who for the most part appear to look on the Persians as foreigners and to remember the old régime kindly. This feeling is very much intensified just now by the Persian economic policy of isolation, which places an embargo on all exports and imports, such as sugar and tea, which are the hillmen's luxuries and can only reach them from 'Iraq; cotton stuffs for the women's long gowns and scarlet trousers, and charcoal, the only export their forests give them: all these objects of traffic are now forbidden, and smuggling is the only trade of the Pusht-i-Kuh. The long mountain border, almost everywhere waterless and twisted into numerous passes and valleys, is impossible to guard, especially since it opens on desert in the west and on to a very solitary mountain region in the east, intersected by ravines and sprinkled with forest, and cut all down its length by the high barrier of the Kabir Kuh. No built house exists here in a square of 100 miles or more. The police have a series of posts along the three main routes, which follow the rivers, the Gangir, the Kunjan Cham, and Ab-i-Danan in the south. The intervening country is only occasionally examined, and here the smugglers go to and fro, travelling rapidly by night with a small goatskin full of water and a bag of flour to carry them through the barren belt. As soon as this is crossed they find themselves among friends and can move from one group of tents to another, scattered at great distances among the forests and the wilderness. They find everywhere help, welcome, and hiding, since the whole country is banded in one vast smuggling league.

Into this secret society I found myself welcomed. Our programme was discussed over glasses of tea, being as a matter of fact a simple affair owing to the possession of passports. The only essential precaution was the providing of the quilt-maker with trousers and a Pahlevi peaked cap in place of his long gown and turban, so that he might pass the frontier post as an orthodox Persian of the new régime. He mourned over the loss of dignity, but compromised by wrapping the turban round the top of the cap and spoiling both the European and the Asiatic effect, a symbol of much that is happening in the East.

In the dusk we rode boldly up to the lonely customs post of Mansurabad and got through, chiefly owing to the fact that, being the first European to attempt such a thing in recent times, there were no regulations to stop me. We were in Persia, with only one other police post between us and the hills. We rode for over an hour in a gathering dust-storm through tamarisk scrub; forded the Gawi Rud under a pale moon, and filled our goatskin at its shallow stream, the last sweet water before the hills. We came in darkness to mounds of earth which cover up the winter fodder of straw outside a Lurish camp, and dismounted amid the barking of dogs belonging to the Zardusht tribe, where our muleteers had friends.

The Zardushtis, spending their winters out in the desert, had built mud walls round their oak-leaf huts, and I passed the night in one of these shelters while the tribesmen in a circle outside, over their politics and tea, sat regardless of dust which now blew wildly over us. By the morning my guides, sleeping on the ground, looked more like Babylonian ruins than Lurish muleteers, and all except the near foreground was invisible. We rode east, and crossed under the telegraph line that goes to Husainabad, the capital of Pusht-i-Kuh; over rolling desert we came to the Gawi Rud, a dry white bed of stones; and there rode up to the last police post. A solitary policeman, busy over the garrison dinner, seeing passports and a seemingly Arab woman wrapped in an abba, let us through. We continued along the river-bed, through bushes of *kurf* now out in purple flower, to where a ruined village showed what used to be the winter quarters of the exiled Vali seven years ago. Thence we climbed up a ridge between two beds of streams, north-east to the pass of Gildar (2800 feet).

This col is only practicable for lightly laden animals and is little used except by smugglers. The path makes straight for it up a steep gully where undrinkable brackish springs feed a few clumps of reeds. Masses of white crystallized rock pour out from the mountain here and there and break away in thin flakes like opaque glass. When we reached the col between two rounded summits, we looked east over an untidy limestone country, scored into valleys by flood waters that eat themselves down into invisible ravines. They were dry, and the country was uninhabited until the rain should cover it with grass and bring the tribes down here to winter quarters. On our left the long ridge of Zamiyah Kuh had a few trees upon it: we followed the base of its precipices, descending a little but not much, since what we had climbed was not so much a col as the threshold of the Persian plateau. The only good spring of water on this way is in a clump of oleanders on the left of the path, about three-quarters of an hour from Gildar. We filled our goatskin and rode on while the daylight lasted, looking for a place to camp. The dust was now behind us and below, the air still and cold. Burnt grass and thorns were all the vegetation about us; black fluted fossil shells, some very perfect, lay strewn about the ground. They are found all over the Pusht-i-Kuh, and are called Sang-i-Peri, the Fairy's Stone, and I have seen them as votive offerings in a shrine. We camped in a gully at the foot of Zamiyah Kuh, out of sight of the path, where smugglers would pass in the night and probably rob us if they knew of our existence. So we kept our fire low and as much hidden as possible.

Next morning we started at 7, as the sun touched the highest rocks of Zamiyah Kuh and lit up an ibex standing on a crag. The path led eastward over whitish hillocks where trees began: oak, thorn, *wan* or terebinth, and bushes of tamarisk and broom. We were through the desolate belt that guards the western border of Persia nearly along its whole length. We had met only one traveller the day before in the desert, and none in the hills; but now Lurs in white woollen tunics, with hair in thick bunches over their ears under white felt skull-caps, with daggers in their sashes and metal-knobbed sticks in their hands, came driving their small donkeys and greeted us with the reserve of the tribesman, who expects to meet more enemies than friends. After three hours a few cairns of stones showed a shrine in sight, and in a meeting-place of

valleys, suddenly green with rice plantations, the Imamzadeh Pir Mohad appeared, a big white building with four blue minarets and a dome.

The land belongs to the Seyids of the place, who call themselves Arab by descent. We stayed for lunch in one of their huts of leaves, and then set out along the Pir Mohad stream, which is no other than the upper Gawi Rud. It slips here through a defile narrow as a corridor between cliffs crowned by trees. These sheer gorges are typical of the country and form its chief difficulty. The streams dive in and out of them as a mountain railway in and out of tunnels, and the paths have to make wide detours, since most of the gorges are impracticable and all are impossible in the season of floods. The soft nature of the rock makes the land very dry; the water eats its way low down. And from all accounts the drought has been increasing during the last ten years, and many streams marked on the Indian Survey map of 1923 (which covers the country up to Kabir Kuh) are now non-existent through the summer.

As we rode and waded among white boulders, and maidenhair, and pools, the gorge opened to a narrow valley, with strata piled in a fantastic disorder of terraces and pyramids and horseshoe circles and slanting ledges left as if unfinished in mid-air. We had to leave the river, which cuts its way direct from the Arkwaz plain, while our path turned left to find an easier approach over gravelly oak tree shoulders. The whole country was now wooded; but the wide spacing of the trees, and the absence of grass or undergrowth at their feet, made them look more like a tapestry design than a forest, each tree alone on its own shadow on the white hillside, spreading big acorns in frilly cups amid leaves larger and darker than ours. At a distance, these thin forests look spotty, without the beauty of our variegated green.

We came in the dusk to a hill above the plain of Arkwaz and looked down on an expanse so lonely that its patches of cultivation and few rows of black tents seemed to be overshadowed more by the solitude around them than by the falling night. No tribesman is willingly out after dark, and we did not descend, but stayed at a colony of four tents on a small spur by a spring belonging to Malik Shahis, who own all the region west of Kabir Kuh. That great ridge filled the eastern sky, running without a break at a height of 8000 to 9000 feet, with its summits Waland Tar and Warzaran at north and south, showing only as rounded hummocks upon it. Our way lay due east, across the southern shoulder of Waland Tar, over the Milawur pass, 8225 feet high.

An English traveller finds a welcome in the Pusht-i-Kuh not only from the traditional friendship of the Vali, but also because most of the men there have been coolies in 'Iraq at some time or other, and bring away feelings kindly to the British. In our Arkwaz tent, the two women also had been in Baghdad. They spent the evening looking with delight at my electric torch and other oddments, and sighing for the city. When they leave it, they return to their hills to live as they have done since the beginning of history; in their tent, shaken by the night wind, with two lambs tethered near the fire for fear of wolves, and the lady of the house baking flat cakes of bread on a convex sort of metal shield laid on the flames, we might have belonged to the earliest days, long before Cyrus. The loose cotton gowns of the women; their hair curled on each shoulder under a lop-sided turban of dark silk; their scarlet trousers with bead-embroidered anklets and woollen fringe over the heel, must have

come down unchanged for many ages. And for the rest, poverty simplified the household furniture. A few copper vessels, a rug or two, and some goat-skins for water was all I could see. When their store of flour is finished, they live on acorns soaked for three days to take away their bitterness, and kneaded into bread: only in good years are they saved from this diet which, they say, is fatal to many of the children. This year the drought was so bad that even goat milk was not to be found, and I got none of the *mast*, or curded milk, on which the Eastern traveller relies.

In the morning, leaving at 5, we crossed the southern end of the Arkwaz plain, where the Gawi Rud, rising below Kabir Kuh, turns a few mills for the tribesmen. A small ruin shows that the Vali used to come here; but the land now is all of the nomads, whose flocks were going out to pasture in long processions of pattering feet, like rain. We came to the outworks of Kabir Kuh, wooded ridges of well-grown oaks with bunches of mistletoe; then began to climb steeply, till limestone needles took off from scree; the oaks gave way to thorn, wan, and at last to enormous bushes of gum tragacanth and a scrub they called *arjine;* the path was so steep that it became impossible to ride. Looking back we could see the limestone chaos we had traversed, speckled with trees to the western hills which the dust cloud hid that rose from the desert below. But when we reached the ridge at 9.45 a.m. we came upon an easy mountain-level of pasture, where in spring the tribes camp for a month or two and look out over the whole of their country west and east. Kabir Kuh is the boundary between the Malik Shahi and Badrai, the two chief tribes of Pusht-i-Kuh. Its long monotonous line, running north-west and south-east, divides the whole region, and is only slightly dented by two passes which cross it—the Puneh and Maimah, south of Warzaran. In winter the snow is a barrier impassable for mules: the whole region is then deserted, since the tribes of Arkwaz go to the 'Iraq borders and the Badrai camp on the warm banks of the Saidmarreh.

The eastern ranges are barely sketched in on the maps. They ran parallel one behind the other below us, north-west and south-east as far as one could see, to where a last outline showed beyond the invisible Saidmarreh. A ridge to the north-west called Barazard ended in the level cliff formation characteristic of the north of Pusht-i-Kuh; but all the easterly hills were round-backed like whales, mostly barren rock, reddish or buff. The valley of the Garau lay in front of them, to which side valleys, deep in oak woods, led down from where we stood. There we hoped to find a lodging for the night. It was touching to see my exiled quilt-maker looking out over the lands of his tribe. "Never did I think to see it," he said over and over again, and told me the names of hills, while I took bearings in an icy wind, to the disgust of the muleteers.

The way down from Milawur is as hard as the way up, and it is not a good pass for animals heavily laden. The range between the two chief summits is very much more indented on its northern than on its southern face. We plunged between cliff walls, more and more deeply into wood, and saw on the sunlit precipice above us eight ibex racing along ledges of rock.

Before sunset we reached Garau, a speck of cultivation surrounded by wilderness. There is a mill with three tents in a side valley out of sight, and one mill in the main valley kept by an old man with seven sons. These mills consist

of a small room built up without mortar into which the water drops and turns a wheel. There was no space for us to sleep in, but the old man brought a bag of flour to an oak tree and we camped beside his fields of beans. We had carried a cockerel up from the Arkwaz plain, and now spitted it on a burnt stick and roasted it, while flour and water rolled into dough cooked under the embers. The seven sons kept watch by fires scattered under other oak trees here and there in the valley; they tried to keep the wild pig from their crops, and a cry of "Wei Khek, wei Khek," taken up from one to the other, echoed at intervals through the night as they drove the creatures off. The wild animals are becoming a nuisance since the disarming of the Pusht-i-Kuh has made the tribesmen helpless. I scarcely spent a night without hearing scuffles with pig or wolves round the outskirts of the camps.

A track enters the valley of Garau by the Milleh Penjeh pass to the west. It comes from Husainabad and leads to Saidmarreh, a large settlement of tents on the river of that name, where the Government keep police. This is probably the route which those Cossacks followed who rode from the Russian to the British Army during the war and came upon our troops on the Tigris. It is the most direct track, though a more northern route by the plain of Shirvan looks easier. Although it is one of the main highways, the country is so lonely that police or customs officials will scarcely travel along it more than once in a month or so. By sheer ill-luck, an important wedding was to be celebrated at Saidmarreh, and notables of that place were on their way to fetch the bride from Husainabad. They were riding up the defile below Garau next morning, just as we were riding down. Escorted by four men with guns, they were surprised to meet an Englishwoman with no armed escort at all; and they spoke of it as soon as they reached the capital, a two-days' ride away.

Meanwhile we rode towards our river. We left the Garau to go through the gorge of Suratai (where it changes its name to Khirr), while we kept on the north of it, along the same valley but on a higher level, a sort of ledge with trees and cultivation here and there. The mass of Kabir Kuh opposite grew steeper. Warzaran, which overhangs Garau, is precipitous on this side like a breaking wave. East of it, smooth black slabs ran up towards the ridge, turning it into a wall. At their base ran a ledge of vegetation similar and parallel to the one we rode along: these ledges were separated from the lower valley by a subsidiary ridge. Looking across, we could see the opposite ledge broken by two cuts of ravines, where streams fall down from the Puneh and Maimah passes. We rode for four hours, losing the view after a time behind our lesser ridge, until we came to a small oasis of apricot and pomegranate gardens belonging to the Musi, a sub-tribe of Badrai to which the quilt-maker belonged.

The Musi, like all in Pusht-i-Kuh, were suffering from the drought. Their garden patch was dwindling away between red walls of hills. I spent two days there, inquiring about the route to Tarhan. At first they said that it was impossible to cross among the lawless men east of the river, where Sagvand raiders infest the passes. But when I remained firm in the matter, it gradually appeared that some of the tribesmen had relatives on the other side, and that by inquiring where the robbers might be beforehand, and moving quickly, the thing could be done.

Luristan Police

Persian border at Mandali

Female costume in north-west Luristan

Female headdress in north-west Luristan

Meanwhile however I heard of graveyards on the western bank, and of ruined cities among two tribes hitherto, they said, unvisited, who had been idolaters till quite recently and were supposed to be remnants of the earliest inhabitants of the land. They were called Hindimini and Larti—from which the tribesmen derive Lur—and they lived in two ravines on the eastern face of Kabir Kuh. Very regrettably, as it turned out, I delayed crossing the river so as to visit these two tribes. We took a Dusani man with us whose lands we must cross, and made eastward, back into the central Khirr valley, towards the Saidmarreh.

In this part of the valley there are legends of fighting in Sassanian days, and there is an old venerated tomb of a Saint Jaber, a Moslem from Medina, whose descendants still own the land. "Shaddad the son of Nushirvan" is said to have had a stronghold in a defile called Tang-i-Kafiri (Gorge of the Unbelievers) through which the Khirr, now transformed into Ruá, in the elusive Persian way, cuts its way into the Saidmarreh. One should always pay attention to these legends, which often remain rooted to places "of battles long ago." I was not surprised to find in the defile traces of masonry where a wall must have closed it below a castle or guardhouse on the height, and also a piece of stucco column, carved in a laurel-leaf pattern and found near the masonry. A cornelian bead and some bronze spearheads, dug up just below, probably belong to an earlier date.

The Garau and the Khirr had both been dry river-beds. We had seen no water except in holes in the ground beside the Musi tents and in an extraordinary round crater called Zemzem, about 300 feet across and 100 feet deep, in the valley bottom below Jaber. But now the Ruá suddenly came to life in the middle of its stony bed at the entrance to the defile and glittered in a blue stream between the rock walls. We followed, often wading, and came into a warmer climate where oleanders grew, and tamarisks, and reeds. The gorge takes only half an hour on foot to bring about this sudden change. It is filled with greenery and birds, between stratified reddish rock 300 feet high or more. Beyond its eastern outlet the Saidmarreh flows, green, swift, unfordable in spring, and now about 30 feet wide.

A strangely menacing silence and solitude lay along the river banks. Except for the grass-grown track to Shirvan, there was no sign of any human life about them. Until the tribes come down in winter, this region is deserted, for the eastern raiders make it unsafe. In the winter however the black tents are dotted along the banks, and when I climbed Kuh-i-Taluk a few days later and gained a more comprehensive view of the river's course, I could see the mud walls which surround the winter tents of the Tarhanis on the farther side, built up on salty limestone foothills where nothing will grow, just above the ploughed river lands. The river itself has made a flat alluvial ribbon varying in width, and then has burrowed itself a further sunken bed filled with tamarisk and reeds. Uninhabited hills, plated with rocky iron-coloured slabs, some wooded thinly and some bare, stand side by side beyond the water. Another black defile lies opposite, the Tang-i-Berinjan, impossible to cross because of robbers. The way to Tarhan zigzags up a naked hill out of sight: I saw it later from Kuh-i-Taluk, skirting the robber defile and cutting through a farther gorge (Tang-i-Siah) into a wide distance of hills and plain. Unfortunately we

Female headdress in north-west Luristan

Female costume in north-west Luristan

did not cross, but turned away, back through the Unbeliever's passage, lunched with some Dusani tribesmen on the site of an old city at its western mouth, and then cut south across a small range called Siahpir into rolling cultivated country belonging to the Bana Parwar.

The Dusan and Bana Parwar between them hold the fertile plain or open valley that rises from Saidmarreh to Kabir Kuh. The track passes through a graveyard with domed tombs, and obelisks which the tribesmen are fond of. They show it to be an old settled land, even to such travellers as are not expert enough to recognize the sites of earlier graves on these gentle slopes. Bronzes and flint instruments are to be found here, and their location goes to show an ancient riverain civilization which followed the great waterway and pushed across the fertile plains to east and west. The mountain recesses of Kabir Kuh, above the line of invasion, were a very likely place of refuge for the earlier inhabitants of the land, gradually ousted by more civilized newcomers. However this may be, the land here shows successive layers of settlement, of which an Islamic mediaeval civilization appears to have been the last. Tombstones, inscriptions, and shards of fourteenth-century glazed ware lie about in the ruined cities of the Larti and Hindimini.

We were unable to come to those tribes that same day. Having made southward for two hours across the plain, we reached a row of unimportant limestone hills and watered our horses at a slightly bitter spring that flows out of a cavern. Then we rode another two hours over treeless downs, south-west, drawing nearer to Kabir Kuh and the forested outwork that still ran parallel and lower at its base. We slept with the Dusanis, in a wind-swept camp.

Next morning we came to wooded slopes, and turned south up the Larti valley, which gradually became a ravine. Kabir Kuh closes it with a wall of black slabs, like the hull of a ship seen from below: there is no way across for any but a climber, though an upper track runs along the level from the Puneh and Maimah passes to the Saidmarreh. Here and there a trickle of falling water made the black rock shine. A perennial spring wells from the shaly foot of the mountain and meets another little stream under a jutting cliff on whose brow an outline of ruins showed the Larti city.

The Larti themselves have dwindled to a few families. Most of them, harried by feuds, fled to settle in Kermanshah, and the Dusanis have seized on the empty land. Three or four households remained on a hillock opposite the old city. They had not even huts, but used the oak trees as tents, arranging their reed screens round the trunk so that the branches and leaves roofed them over. They gave us all they had, a mess of vegetable marrow and bread dipped in fat, while they spoke of their ancient lineage with the quiet dignity of an old aristocracy.

I spent the afternoon exploring the city, which seems to be Islamic on Sassanian foundations, with probably an older history behind it. An Islamic carving in running script is there waiting to be deciphered. The walls and gatehouse, all in ruins, and a number of tombstones scattered about the top of the town, show it to have been a considerable place. Under the cliffs are more primitive graves. I examined two of them, but came only to the negative conclusion that, as far as I could hear and see, the Luristan bronzes never

reached to these mountain recesses. They will not be found, I feel convinced, far from the plains and waterways.

The Hindimini live in a parallel ravine east of the Larti, beside a chaos of grey boulders. They too have dwindled to a few families, famous for their idolatrous past, the beauty of their women, and their skill as shoemakers. We rode across to them, along the ledge that forms the base of Kabir Kuh, and descended on their tents in the ravine just as darkness fell and a bleating of flocks filled the shadows. Their old city must have the same sort of history as that of Larti, but its ruins climb in terraces under the cliff side in a less commanding position than the other. Here too the graves gave no result, and I could hear of no bronzes.

A wandering Dervish shared the hospitality that evening. He sat cross-legged, the Hand of Abbas, cut out in brass at the end of a rod, stuck in the ground behind him and appearing over his shoulder. He came from a monastery over the hills, whence he travelled to see the world, and spoke with pleasant detachment, as an onlooker on life. As we sat on carpets in a circle, for our hosts were well to do, I noticed, as I have done often before, what a charming manner of conversation the tribesmen have, full of general intelligence and breeding, never interrupting or gesticulating, and seeing to their guests' comfort with the quietness bred of their constant habit of hospitality.

Next day, after digging up two graves and finding some shards of pottery, we returned to Larti by a lower route, and on the day after rode leisurely back over the Dusan plain, stopping to examine two graveyards where flints and a small piece of bronze showed that we had returned into the zone of antiquities. There was no time however for more than a superficial visit. In the heat of the day we rode on to a small camp of Dusan in a hollow, and were just cooling down in the best tent, when three policemen, who had been following my tracks for days, trotted suddenly into our midst, and spread consternation among my hosts.

The policemen's lieutenant began by being very suspicious until he saw that we had passports. When I showed him the contents of my saddle-bag, which happened to be a skull from a Larti grave wrapped up in my burberry, he gave me up as a lunatic and left me to be dealt with by his superiors at Husainabad. He did not say I was to be coerced, but expressed it with true Persian politeness by promising to accompany me wherever I wished to go. I could return to the Musi as I had intended, and he would rejoin me after a short tour among the tribes to elicit, as I imagined, more news about my doings. He caught us up as we rode along the Jaber valley in the dark that evening, and was so horrified at the riskiness of the proceeding that I realized how one can only wander at night in Luristan *without* a police escort.

I made an effort to take the Lieutenant at his word and still get horses from the Musi for Tarhan. The horses had all mysteriously vanished. Cross-examination elicited the fact that threats had been used to prevent their being supplied to me. The tribesmen however were independent people, and offered to take me notwithstanding; but it would almost certainly have brought down punishment upon them, and I decided reluctantly to ride first to Husainabad and explain myself to the Governor.

The route we took was back along the valley to Garau, where we lunched

by the upper mill. The police were pleasant people, mostly of tribal extraction themselves, from the settled districts round Kermanshah and Harsin. They get 10 tomans (about £1) a month, and 8 for their horse, which they themselves provide, and they all seemed content with the service. They were not rough with the people when we halted, and assured me that all was paid for that we consumed; but the tribesmen's obvious unwillingness to receive us, so different from their usual generosity, and the dismay caused by our appearance, made one suspect another side to the question.

The Pusht-i-Kuh is not nearly so warlike as eastern Luristan, and five hundred police keep it under control and disarmed. But the régime is undoubtedly unpopular. This seems to be less the fault of the officials than of the Government policy. In other parts of Persia the police have made commerce safe and the people are grateful. But along the frontier, the repression of commerce is their job. Opium, cotton, tea, sugar, and antiques are not allowed to circulate: the roads are safe, but this benefit is completely annulled by the fact that nothing profitable is allowed to travel along them.

Apart from the police and an army garrison at Husainabad, there is a corps of Tufangchis, or tribal volunteers, whose headquarters is Saidmarreh. Many of these are recruited from among the fighting tribes of the eastern bank. They are given a little money and some land, and are expected to serve as required. A band of a dozen or so of them came down as we rode up, escorting the tax collector, a young effendi in European clothes who showed an unusually intelligent interest in the country. He told me about ruined castles of Shirvan, whose wide plain I had seen on the north-west from a hill in the Musi land. The tax collector lunched with us and then rode off with the Tufangchis—wild men with moustaches and long hair, in white abbas, slung about with knives, cartridges, and guns, a sight to make the most recalcitrant hasten to pay his taxes. As for the Lieutenant, he knew his district so little that the very name of the Larti and Hindimini tribes was new to him. He now fell sick, and rode as best he could under my sunshade, in a high fever, while I dosed him with what I hoped were suitable pills and wondered what would happen if I reached Husainabad with only the corpse of my captor.

The track west of Garau is very beautiful. It rises through oak woods to the low Milleh Penjeh pass (5600 feet), with the points of Waland Tar and cliff-tops of Saiwan and Barazard above it on either hand. The pass was a two-hours' ride from Garau, and from it we looked out over more forest, and rode, still in the same direction, along the base of Kabir Kuh, whose end we could see before us, where the Kunjan Cham valley cuts it. We rode along the level under trees, crossing at intervals dry beds of the Baliaqin stream which pours itself into the Ab-i-Aftab and thence into the Kunjan Cham. Aftab is the name of this region. It belongs to a large tribe, the Mishkhas, who grow tobacco and winter on the borders of 'Iraq east of Tusek. Their huts only began a four-hours' ride west of the pass, and we rode towards them in solitude and darkness, after turning north from a good spring called Chashmeh Qal'a Malik into a subrange of limestone hills: the dim whiteness underfoot was all we could see in the night, till we heard water around us, and smelt the coolness of cultivated earth, and saw the fires of the Mishkhas scattered in a wide basin of the hills.

An old man whose tent we first reached was too poor to lodge us; he and his

wife and a new-born calf took up all the available room. But he refused to lead us to any one else. Threats, shakings, and curses had no effect on him. He would never be forgiven, he said, if he brought the police to his neighbours. He was carried along by the scruff of his abba at a policeman's stirrup, and we finally drew up to a larger tent where a better welcome was given.

We were now in country which has been mapped out. An Englishman was mentioned to me continually, who travelled here nine or ten years ago with a wife and seven tents. I therefore troubled no further about my compass, the taking of bearings having also become rather difficult because of my escort. We spent the morning riding up and down small limestone hills, white and glaring and dotted with stunted trees, round the south and west of the massif of Shalam, and crossed several dry watercourses that descended from it. We passed a track to Mandali, and at noon scrambled up a steep short slope on to the plain of Husainabad, or Deh Bala, as it is still more generally known.

This landscape is quite different from that of eastern Pusht-i-Kuh. The hills, with the exception of the fine mass of Manisht Kuh above Husainabad, are long ridges with flat cliff tops. The plain is more open than anything I had seen so far; studded sparsely with big oaks in ploughland, and stretching to a flat horizon northward. No forest is visible, and there is little water. It has long been cultivated land, and the gentle rise of the ground often hides ancient graves. The people tell of many finds near Husainabad, carefully concealed from the police. They also offered me fossils of sea urchins, as genuine antiques.

My Lieutenant was so ill that he had to ride on the pack saddle while I pranced into the capital on his Arab bay, to the surprise of the Commandant of Police, who was out to meet us. He was a trim and intelligent Tehrani, who was for taking me straight to the Governor, but saw the force of my plea for a preliminary wash, and lent me his own house for the occasion.

Husainabad has only begun to exist as a town within the last two years. It is laid out in four or five boulevards, and Kermanshah workmen are running up houses and shops. Any one who likes can buy land from the Government at a nominal price and quarry stone in the side of Kuh-i-Shalam, half an hour away. Tribesmen are beginning to do so, but unwillingly, and most of the inhabitants still live in streets of tents and oak-leaf huts outside the official centre. The truth is that there is not enough water at present in the country to make it possible to give up the nomadic life; the population could not live in the same place all the year round. The tribesmen do not like the few townspeople of Husainabad, and only the army garrison in its barracks, and the police in the old fortress of the Vali, keep the town safe.

I spent four days here, waiting for instructions from Tehran. The Commandant was most courteous, and called on me twice a day in a small house which was found and furnished with all necessities by the efforts of various neighbours. I must say here that I have been very fortunate and never met anything but kindness from Persian officials, even under trying circumstances. The Governor, an able and pleasant young man in a very new palace decorated with coloured stuccos, was also friendly, but amused. My travelling alone among the tribes gave me an excessive reputation for courage, owing, I believe, to the fact that it would possibly be risky for a Persian official to do the same.

It was obvious however that I was not to be allowed to travel farther. Travellers from 'Iraq are suspect. Apart from this, and the natural fear that something might happen to me in their district, every one was very anxious that the turbulent condition of eastern Luristan should be as little investigated as possible. An order came from Tehran to take me back to the 'Iraq border the shortest way. Three policemen and a sergeant were given to attend me. The Commandant saw me off at the outskirts of the town. The escort led the way by a short cut northward over the spurs of Manisht Kuh, riding correctly with a scout ahead and three men behind me, while the quilt-maker brought up a melancholy rear.

There is a new and only motor road in Pusht-i-Kuh which goes from Husainabad to a point on the Karind–Kermanshah road. It was not completely finished when I saw it, though cars already used it. It runs in a wide north-westerly sweep from the capital, and turns back towards Manisht Kuh along a wooded valley. Here we came upon it, after rounding Manisht Kuh through steep and sudden foothills of white or grey detritus. Shepherds in the oak trees were tearing down branches to feed their flocks, who waited huddled below, obviously accustomed to this sort of meal.

We lunched at a hut among the valley trees, and then followed the road through gangs of astonished workmen. It crosses the ridge of Kuh-i-Ranu by a tunnel blasted through the rock, and comes out into the more northern valley of Aivan. These valleys, and those leading to Shirvan, etc., all branch like spokes of a wheel from Manisht Kuh, which rises on this side in bold shoulders of pasture to a rounded summit where the Aivan take their flocks in spring.

Their camp at this season was at Sarab Bazan, one and a half hours' ride from the tunnel in a shallow valley. This is the source of the water which later becomes the Gangir river and enters 'Iraq at Mandali. A police post stood there on a low rise strewn with grey stones, probably the site of an ancient town. Another ruin, they told me, is on the round ridge of Bani Kuh opposite, where water gushes out on the top of the hill. Hampered by my excessive escort, I was unable to investigate. On the other side of the ridge, eastward, the big tribe of Asiman also have many ancient sites; beyond them, Shirvan is full of Sassanian ruins; and as we rode next day, various mounds showed that we were going through a once settled region.

In the evening light the treeless valley with its strips of cornland looked very peaceful. Two lines of sheep and goats were coming down to the tents from either side. The women were filling their water-skins at the sources of the stream, which springs out of the ground in blue pools, led away in leats among the fields. The Aivan made us welcome in their tents. They are not independent tribesmen like the Malik Shahi and Badrai; the Shah is their landlord and shares the harvest. As we rode along the valley next day, and then turned west off the road to follow the Gangir stream, we saw it being counted. The corn was divided in two heaps. The owner buries his lot in the ground, to find it when he returns from winter pastures, or puts it in the small huts which the Government has made him build but which he cannot be induced to live in. I have not yet met one of these tribesmen who does not prefer his tents.

The Gangir goes through a gorge called Shamiran, which we skirted, riding through stunted oak scrub, the last of its kind. From the highest point we looked

west over a red mountain desert, the same sort of inhospitable country we had crossed on our way out. But here we had the Gangir water beside us, and next day we rode by the river for a long stage of ten and a half hours, through the winter lands of the Aivan.

Although there were five places where rice was cultivated on the way, varying from the fair-sized hollows of Ban-i-Chinar, Sepá, and Var Gatch east and west, to the tiny patches of Kainmaru and Gangir in between, the general impression of this country is one of inexpressible desolation. The river runs sometimes through hills of crumbling red, sometimes under a fringe of reeds high above the rider's head, tufted with flowers like plumes. Oleander, caper, and tamarisk appear lower down in its bed. But nothing can mitigate the surrounding nakedness, and the impression of desolation increases as one rides hour after hour through the shadeless chaos. The water is violently blue; but the absence of vegetation takes away all sense of the gentle influence of streams. The huts are miserable affairs of reeds such as earliest man may have invented, and their few inhabitants are victims of malaria. Here and there are remains of an important thoroughfare, Islamic bits of masonry, aqueduct, and domes, and earlier cemeteries with deep rectangular graves looted for bronzes.

Just above Var Gatch a considerable settled place must once have existed in an opening of the valley, and Var Gatch itself has level ricefields and well-built reed huts, but so many mosquitoes that we thought better to leave the Aivan country and ride in moonlight after supper to the huts of Saumar. We were now in level stretches where the stream begins to meet the 'Iraq plain. Carried about in small watercourses, it irrigates fields of maize, which now swallow up the water which once fed the Mandali gardens, when 'Iraq could send up soldiers to settle the matter. As we jingled along in the moonlight, a policeman galloped aside to chase five pigs out of the crops; their clumsy black silhouettes humped off one behind the other. At the tents of Saumar we found a man sleeping across a threshold with the flocks huddled in a circle near by. We soon had mattresses provided, and woke next morning in a large three-roomed hut built of upright reeds with a flat roof and a sort of battlement all round made of their leafy plumes. Saumar is the last tribe of the border and lives here all the year round. It has a few buildings: the police post, custom house, a rest-house for officials, and a garden of two acres or so belonging to the Shah, a dreary place newly planted.

An hour's ride next day along the wide bed of the exhausted Gangir led us to a small round tower which is the actual border. Here we parted in friendship from our escort, and reached, an hour or so later, the house of the Naqib of Mandali, who was surprised to see in what a dilapidated condition one emerges from travels in Persia.

The stages on this journey were taken at a very leisurely pace and could be made more quickly.

A NOTE ON THE ANETO GLACIER OF THE MALADETTA MASSIF, SPANISH PYRENEES

WERNER HEYBROCK

IN July 1931, as already reported in this *Journal* (vol. 79, p. 247, March 1932), the French geologist Casteret succeeded in demonstrating that the glacial waters which disappear in the Pyrenean swallow-hole of the Trou du Toro reach finally, not the Esera, but the Garonne, and that the drainage area of the Garonne must be taken, in consequence, as extending to the Maladetta massif. Somewhat loose references having been made, both here and elsewhere,[1] to "the glaciers of Maladetta" in this context, it is well to recall that no glacier on the south side,[2] either of the Maladetta itself or of the massif to which the name has been extended, comes into the question, and not all of the glaciers on the north side. It is not yet known what becomes of the melt-waters of the Albe and North Maladetta Glaciers, shown in the map[3] as disappearing from the surface near the Rencluse, at 2140 m., but, an attempt to clear up the point having apparently failed,[4] Mallada's statement that these are headwaters of the Esera[5] holds good provisionally; they cannot, in any case, reach the Trou itself,[6] although it is conceivable that they are diverted by underground capture into the same system as the Trou waters. There remains, in fact, only a minority of five glaciers of the massif, the Moulières, Salenques, Tempêtes, Barrancs, and North Aneto Glaciers, which may be ascribed with certainty to the Garonne drainage.

The largest of these, and probably the largest of the Pyrenean glaciers, is the North Aneto Glacier, usually described as in the title to this article. This was examined by the writer in September 1931, in the course of a stay of several days at the Rencluse Hut (*c.* 2150 m., just below the tree-line, estimated at 2220 m. on the neighbouring, north-facing slopes). The lowest point reached by its ice (Plate 4) was found at *c.* 2600 m., so that its total length, the *névé* included, is only 1200 m. and materially less than the breadth, of approximately 1800 m. There is no tongue, merely a number of short projections of ice extending beyond the terminal periphery, and no question, of course, of a glacier of the valley class.

At the same time, it belongs to no one clearly defined type: the small eastern section, overlooked by the summit of the Pico de Aneto (3404 m.), is hanging; the very broad western section, backed by the ridge running from the Pico de

[1] *Geogr. Zeitschrift*, 38 Jahrg., 1 Heft, 1932, pp. 37 f.

[2] These include the following glaciers: the West Maladetta, Crequeña, South Milieu, South-west and South-east Aneto, South and East Margalide.

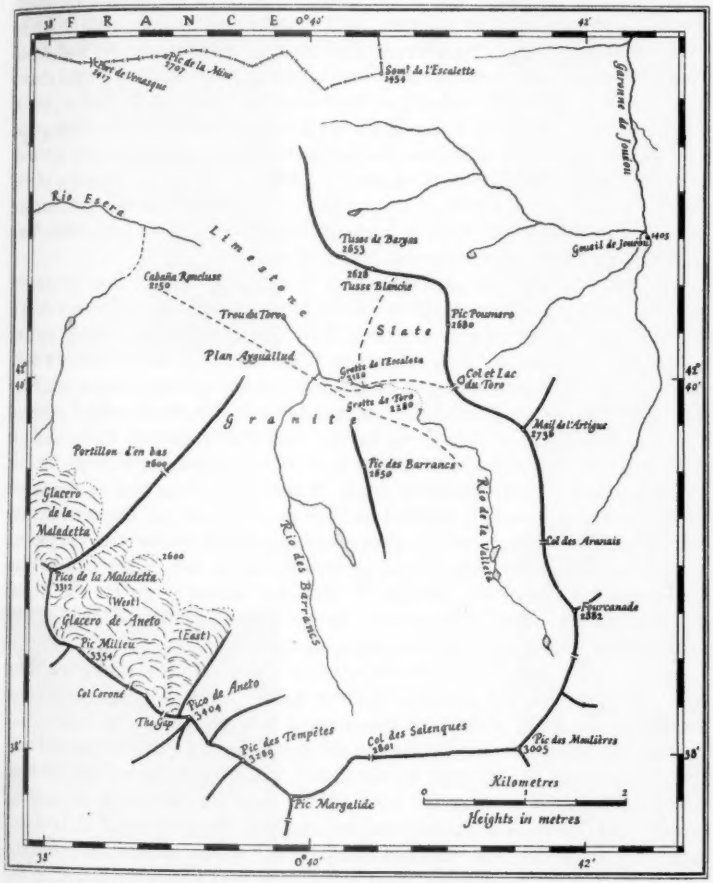
[3] *Service Géogr. de l'Armée*, 1 : 50,000, enlarged from 1 : 80,000, No. 252, Bagnères S.O.

[4] L. García Sáinz, "Les phénomènes d'époque glaciaire et d'évolution Karstique dans la vallée du Haut-Essera (Espagne)," *Geogr. Annaler*, Arg. XII, Häft 4, 1930, pp. 321 ff.

[5] L. Mallada, "Descripción física y geológica de la provincia de Huesca," *Mem. Com. Map. Geol. Esp.*, 1878, p. 83.

[6] This is evident from the topography, the point in the main valley directly below the Rencluse being 1·7 km. distant from the Trou and over 100 m. lower. The writer was unable to find the alleged swallow-hole during his visit and had the impression that these waters find their way by the surface to the Esera.

la Maladetta (3312 m.) to the Pic Coroné (3310 m.), is of the plateau type, while the ice on the line of junction, leading up to the Col Coroné, may fairly be described as trough ice. García Sáinz (*op. cit.*, p. 334), on the ground of a movement of rotation observed in the body of the glacier (probably in the overflow from the trough), ascribed it to a mixed type. This phenomenon, at



Sketch-map of the north-east part of the Maladetta massif

most merely local,[1] could not, in itself, justify the ascription, but the two sections do, in fact, differ essentially throughout, and especially above the contour of 3000 m.: their crevasses run in consistently different directions; the eastern ice has a higher rate of flow, of which the incidental effect is to bring together ultimately ice of different ages; the eastern *névé* moreover is fed from

[1] There is no trace of it visible in Plate 1, which includes three-quarters of the glacier.

smaller reserves of snow than the western, the snowfield being more exposed to high winds,[1] but its pitch is steeper and its exposure more northerly, so that loss by insolation is less than in the wind-sheltered, more southerly-facing, western section. On the balance, the thickness of ice is much the same in the two sections.

No surface moraines are to be seen. At the north-western extremity, melting exposes a ground moraine, with granite blocks sometimes of several cubic metres (Plate 4). Near the westernmost projection a newly abandoned frontal moraine was found in conditions indicating a recent loss by the glacier of some 15 m. in length and of 5 m. in thickness. The broad, shallow, lateral moraine of the west flank is seen in Plate 1, foreground. The same photograph gives some idea of the crevasses, the much-fissured ice of the middle distance overlying an exceedingly broken surface, while the simpler fissuring of the Aneto section, which begins at *c.* 3300 m., corresponds to the simpler surface of the underlying slope. Plate 5, representing a fissure, some 4 m. wide, from this section, shows the structure and pitch of the *névé*.

The present thickness of the ice does not appear to have been measured exactly, but it is unlikely greatly to exceed 50 m. A clue to its thickness during the Ice Age is given by the form of the Pic des Barrancs (2650 m.), on the eastern side of the valley of the Rio des Barrancs. This mountain culminates in a well-defined pyramidal peak rising on each side by an abrupt step, from a relatively flat high ridge (Plate 3), and the contrast between the sharp-edged pyramid above and the rounded-off forms below, from the shoulders downwards, is most striking; we cannot but see here the marginal work of the Aneto Glacier at its maximum. Corresponding levels of the valley floor and of the upper limit of polishing being estimated at 2200 m. and 2580 m. respectively, the thickness of the ice at the epoch of maximum glaciation can be stated as 380 m., strictly speaking $380 \times \cos$ (angle of inclination of the valley bottom), an amount which agrees very well both with the figures given for the Alpine glaciers and with the existence of a terminal moraine near Sahún, 28 km. farther down the Esera valley, at 950 m. altitude.[2]

At this epoch, the Pic des Barrancs stood at the point of confluence of ice from two large feeding-grounds. Besides the ice from the large, cirque-like ground to the west, which was compressed into the narrow passage of the Barrancs valley, ice descended also on the east, from the Pic Moulières, Fourcanade and Mail de l'Artigue, by the valley of the Rio de la Valleta. In both valleys, a bend, at or near the point where the limestone zone is reached, brought the ice to bear directly on the northern flank of the Pic. It is not surprising therefore that marks of intensive ice action should be preserved here, and it is to be supposed that the erosive and loosening action of the combined glaciers on the dolomitic limestone of the bed in the neighbourhood of the Trou du Toro would be very considerable, assisting perhaps in

[1] The strongest winds come from the western quadrant. The effectiveness of the shelter afforded by the mountain ridge is shown by the large number of dead insects, butterflies, and even song-birds, beaten down in the wind prevailing above, which are found on the surface of the western section of the glacier.

[2] Sahún had already been indicated roughly by Obermaier ('Fossil Man in Spain,' 1925, p. 139) as the limit of the Esera Glacier; but a detailed account of this and of the other glacial features of the valley is now given by García Sáinz in the article cited.

1. Pico de Aneto and the glacier from 3100 m. on the N.E. ridge of the Maladetta

2. Looking towards the north flank of Pic des Barrancs (middle distance) and Mail de l'Artigue (background)

3. Looking E.N.E. from the Portillon d'en bas at a height of 2600 metres

5. Fissure in the eastern section of the Aneto Glacier

4. Termination of the Aneto Glacier; Pico in the background

preparing the conditions for the important diversions of drainage which have been effected in this zone in post-glacial time. The analysis given by García Sáinz (*op. cit.*, p. 335) shows however that the Trou limestone is exceptionally pure and soluble, so that the valley is peculiarly exposed at this point to subterranean attack.

It remains, in conclusion, to indicate the limits of the limestone zone as observed by the writer. The passage from the granite of Pic des Barrancs and the slate of Pic Poumero to the limestone (of the Tusse Blanche, etc.) is marked by deflection of the valleys, as stated, and also by a series of Karst forms—two long grottoes on the Rio de la Valleta, swallow-holes, underground water-channels, etc.—which have been described by García Sáinz (*loc. cit.*) and by Casteret.[1] The line of junction crosses Plate 3 on the left side (right side in the photograph) of the mouth of the U-valley at the foot of the Pic des Barrancs, and the limestone extends westwards to the Port de Venasque at least, where crystalline limestones were seen on the crossing from Bagnères-de-Luchon. Below the Trou, in the relatively dry, "beheaded" section of the valley, numerous sink-holes betray the limestone underlying the *lehms* and granitic sands of the surface. Near the Rencluse hut, the contact of the cavernous, craggy limestone with the granite dipping, in sheet-like masses, N 35° is again observed. Higher up, the small lake formed by a morainic bar is probably on the granite; García Sáinz, who gives a correct account of the origin of the lake, overestimates its altitude by some 300 m., the true altitude being at most 2300 m.

Discrepancies of this order, together with the frequent confusion between the Aneto and Maladetta (*sensu stricto*) glaciers and other errors of confusion[2] point to the need for a full and accurate map. It is to be hoped that this will be provided by the new edition, understood to be in preparation, of the French map cited above.

[We are grateful to Mr. Robert Aitken for translating the above article from the German and for making certain suggestions which the author has been pleased to accept.—ED. *G.J.*]

[1] *Bulletin Pyrenéen*, 194, Oct.–Dec. 1929, pp. 136 ff. The article, although unsigned, seems to have been written by M. Norbert Casteret.

[2] The *Geographische Zeitung* and *Bulletin Pyrenéen*, *e.g.*, in the articles cited, confuse the altitude of the Tusse Blanche, actually 2628 m., with that of the Pic Poumero, 2680 m.

NOTES ON THE MOUNTAINS ABOUT TATSIENLU

J. H. EDGAR

THE article on "The Mountains about Tatsienlu" (*Geogr. J.*, vol. 75, pp. 345–353) deals with the majority of travellers who have been in a position to discuss these mountains, but the names of Potanin, Prince Henry of Orleans, Doctors Tafel and Assmy, Captain Stötzner, General Pereira, L. M. King, and Dr. Heim are omitted. The author also seems unaware that in a biography of the late Dr. Z. Loftis, of Batang, published about 1910, a vivid description of the Tatsienlu Mountains is on record. The present writer published a paper, "The Gangka—a peak in Eastern Tibet" (*J. West China Border Research Soc.*, vol. 3, pp. 157–161) before seeing the article in the *Journal*.

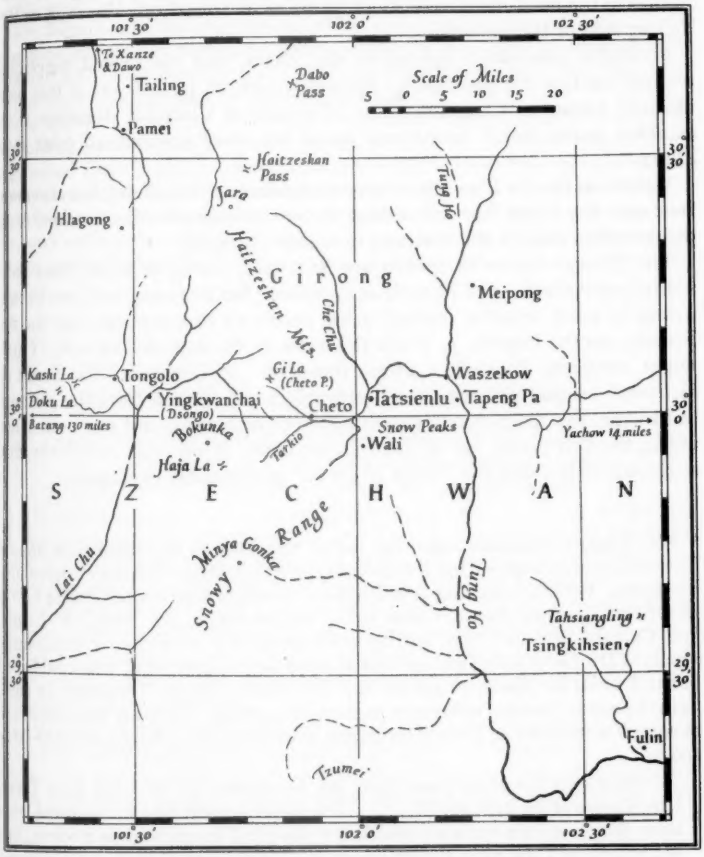
The following comments upon the accounts of the travellers quoted may be of interest. Kingdon Ward's remarks are approximately correct; he is also near the mark when he suggests 20,000 feet for the Tatsienlu Range.

The "Ta Hsiang" of Gordon's account does not mean the "Great Elephant," but the "Premier Pass"; and I know the Tzu Mei more particularly as a col and a non-Chinese hamlet 4 miles south of the Gang Kar lamasery. The name may be loosely applied to some adjacent mountains, but not seriously to any system continuous with the Gang Kar [the "Kunka" of the original article] complex. I do not know of any feature in the locality indicated by the sketch-map that could claim the name "Tzu Mei" (Tibetan: T'si Min). Regarding Gill's account, the Gang Kar is not seen from the valley roads on the T'ung side of the Gi La or Cheto; what he saw when looking back the first time was the short Tatsienlu range. The Ka Ji (Kashi La), 50 to 60 miles westward of Tatsienlu, gives just such a view as Gill describes. But my belief is that he was speaking of the Zhara (Jara) and looking at the Gang Kar!

In the narrative of Szechenyi's Expedition there is again a description of a journey towards the Cheto col. But on, or near, the summit the narrative becomes confused. In the first place, on the Pass there is no vista of specially arresting mountains, and even the higher saddles or lower plateaux would only reveal an ordinary snow-field and a rather poor view of the Zhara. From the Ka Ji however it is possible to admire not only the great rim of the Gang Kar complex, but also an intrusion of serrated peaks which run between the T'ung and the Che Ch'u from the Hai Tzu Shan to Tatsienlu. This may explain the suggested confusion. In any case the most northern peak of the great rim is the Zhara and the southern one the Gang Kar. About 90 miles north of the Gi La, just east of Taofu or Dawo, we have crossed the Yalung–T'ung divide above glaciers and near snow peaks. To the north-west—again perhaps 100 miles—on the left bank of the Yalung is another snow peak, the Kawalori of Coales, which is detached from the snow-clad Kanzè system on the right bank of the same river.

Returning again to Loczy's "Bo Kunka" we find that this name, so pronounced, is the one given to-day in every case where the southern peak is concerned, and this traveller's description, also, is admirable. Evidently Kreitner's "Kunka Range" (literally "Snow Mountains") east-north-east of the main peak is also correct, or nearly so.

The Ajala crossed by Stevens is roughly halfway between the Gang Kar and Ying Kwan Chai. The country representing the more northern part of this division consists of rolling downs with excellent pastures. This is true in the very region chosen for the position of the "Bo Kunka" in the sketch-map. The Chengtu Expedition made its observations not far from the same spot.



Sketch-map of the country around Tatsienlu

Stevens's "Ying Kwan Chiai" and Kreitner's "Dzong Go" are the same place and are the Chinese and Tibetan rendering respectively of the same word.

As regards the name Gangs t'Kar (Kunka), the word as written in the Tibetan script must mean the "White Ice Mountain," a common name for snow-clad peaks in eastern Tibet. In this very region there are three or four "Gangs t'Kars" modified by regional names. Since Dr. Rock's visit the qualifying Minyag has been added to *the* Gangs t'Kar. The explanation is simple. Dr. Rock came from the south, and his men, catching their first

glimpse of this superb feature, exclaimed: "The Gangs t'Kar of Minyag." But "Bang Gangs t'Kar" (pronounced "Bo Gang Kar") is now as it was in Kreitner's day the local designation. When at the Gang Kar Monastery in 1931 its scholarly abbot gave me, in the Tibetan script, the words "Bang Gangs t'Kar," asserting that they represented the official name. The same applies to the head monastery about 35 miles in a southerly direction on the Yalung side of the mountains.

Rockhill's description applies to the Zhara, and his second suggestion reminds us that the principality through which he passed was at that time officially known as Chag La. "The Mountain of Chag La" therefore is an excellent guess; but I have never heard the word pronounced other than Zhara.

Wilson on the Ta P'ao refers more particularly to the Zhara, but also must have seen the Gang Kar and indeed all the other ranges. Coales alone of all the travellers renders the northern mountain correctly.

The Tibetan names as spoken are, as a rule, widely different from their written equivalents. The Zhara is an exception; but this name has been written wrong by every traveller except Coales, unless we may suppose they use the French, not the English, *j*. While the name of the state and its ruler "Chia" might vindicate Rockhill, a literal translation of Zhara as "the Fence of Helmets" accords well with the topography. For, viewed from the plateaux of Minyag, the Zhara surely suggests a fence or barrier, and one peak is not unlike the ceremonial hat of some Lama cults. It was this peculiarity that suggested to Rockhill the "Horn of China" as a possible explanation.

Mr. Edgar's additions make the list of travellers in the mountains around Tatsienlu more complete, but it does not appear that all have left their impressions on record. Potanin's account is in Russian; Bonvalot's account of Prince Henry of Orleans' journey does not refer to the mountains; L. M. King, Dr. Assmy, and Captain Stötzner have left no easily accessible accounts. A preliminary report of Dr. Heim's visit did not appear until 1931: a note upon it was published in the *Journal* for January 1932 (p. 74). Dr. Tafel's 'Meine Tibetreise' (2 vols., 1914) however contains references to these mountains, which are translated here to complete the record. He was travelling southwards from Kanze, in April–May 1907.

> "Once over the Heka pass, there are two routes to Tatsienlu from Dawo [the Taowo of the 1/M sheet]. . . . The western route which I followed leads over debris-strewn terraces, which are dissected by numerous streams, but yet belong to a common elevated surface of 4000–4250 metres. I experienced fine weather, and the peaks of Dschara re (Zarsun) and the Hai tse schan massif, which lay on my left hand, were a magnificent spectacle for two days. The main summit rose about 2000 metres above the track. Far to the south, the great holy mountain of Bogungga, well over 6000 metres, beckoned, while to the west, towards Li-tang, high steppes (4000 metres) stretched to the far-distant horizon. No soaring peak or summit attracted one's attention in that direction. Fine meadow land covered an old, interminable peneplain, upon which myriads of yaks might browse. . . . This is Minyag" (vol. 2, p. 200).

Dr. Tafel gives (vol. 1, p. 193) two panoramic photographs of "Dschara re" (Jara) from the west at 4100 metres, and from Dabo pass on the east. The first

may be compared with Nos. 4 and 6 of Mr. Stevens's sketches. There is also a distant photograph of "Bogungga re" opposite p. 192, vol. 2.

Other travellers in the Tatsienlu region are the Indian surveyor, A. K., Mr. E. Colborne Baber, and Sir Alexander Hosie.

The remark that Gill was probably confusing Jara and Kunka is difficult to accept, as Gill marks them both distinctly on his route map.

Mr. Edgar's conclusions confirm those to be drawn from the travellers' narratives collected in the original article in the *Journal*, that the "Bokunka" of Kreitner and the "Minya Gonka" of Stevens are the same peak, but that it lies farther south than the position given by Kreitner.

The *Alpine Journal* for May 1933 states that Messrs. Terris Moore and R. Burdsall made the first ascent of "Minya Koonka" on 28 October 1932. They approached from Tatsienlu, but found the eastern slope impossible, and ultimately ascended the north-west ridge, establishing a light camp at about 21,500 feet. From this camp the final ascent was made. The weather was very fine, but the party suffered much from frost-bite. The summit is given as *circa* 24,000 feet, as against Kreitner's 7600 metres (24,900 feet).—ED. *G.J.*

THE WORLD-MAP OF PIRI RE'IS, 1513

DIE VERSCHOLLENE COLUMBUS-KARTE VON 1498, in einer Türkischen Weltkarte van 1513. By PAUL KAHLE. *Berlin and Leipzig: Walter de Gruyter & Co.* 1933. 10×7 *inches;* 52+9 *pages; facsimile maps. M.*5

THE recent discovery, in the Serai Library at Constantinople, of the western half of a world-map drawn in 1513 by the noted Turkish Admiral Piri Re'is, would in any case have been of interest to students of early maps, but it has even greater claims to attention from its author's statement that for the new lands in the west he had followed a map by Columbus himself. Of original maps in which the new western discoveries were shown, not one has survived which is the actual work of the navigator, so that if Piri's statement can be trusted, we have in his map a new side-light, if nothing more, on the ideas of the Genoese on the scope and meaning of his discoveries.

It was in October 1929 that Professor A. Deissmann, then engaged in researches in the Serai Library, called the attention of Dr. Paul Kahle, of Bonn—a Turkish scholar who had for some time been busy with the publication of a previously known work of Piri Re'is, of which the first part appeared in 1926—to the existence of the map in question, and his interest in it was at once aroused. In the known work of Piri—elaborate sailing directions for the Mediterranean, with which as an active seaman he was thoroughly familiar—the author states that he had previously drawn a world-map depicting the newest discoveries, and that he had offered it to Sultan Selim in Cairo. This must have been in 1517, the year of the Turkish Conquest of Egypt. The newly found map bears an inscription stating that it was drawn by Piri Re'is at Gallipoli in 1513, and there could be no reasonable doubt that it represented a part of the map given to the Sultan in 1517. (No trace can be found, unfortunately, of the eastern half, which, it is suggested, may have been taken by Ali Ekber when sent to China by Sultan Selim to collect information about that country.) Dr. Kahle made a careful study of the map and soon reached the conclusion that the Columbus map used by its author was no other than the lost map sent by the navigator to Spain in 1498.

The probable channel by which the map reached Piri's hands is satisfactorily indicated by a legend on the World-map telling of a Spanish slave owned by Piri's uncle, the famous Kemal Re'is, who (the slave) had three times made the voyage to America with Columbus, and we have the probable date of his capture when we read in the above-mentioned Mediterranean book that seven Spanish ships were taken by Kemal near Valencia in 1501; also that Piri had seen in them objects brought from America, including head-dresses of parrots' feathers.

Dr. Kahle described his preliminary conclusions two years ago at the Orientalist Congress at Leiden, and having since made a further study of Columbus literature, now puts forward his arguments in some detail (while promising a larger work for the benefit of students) in the brochure now under review. His main points may here be summarized.

In the first two sections, Dr. Kahle treats of Piri as a seaman and geographer, and describes the general features of the World-map. He quotes Piri's account of the sources on which it was based. Piri had used, he says, twenty different maps, including, in addition to Ptolemy maps and "Mappamondos," an Arab map of India, four up-to-date Portuguese charts, and finally the map of Columbus from which he had taken certain coasts and islands with the names bestowed by the navigator. We find, in fact, the results of the Portuguese discoveries carefully shown in Africa and South America, and as the Admiral's general trustworthiness is amply vouched for by his work on the Mediterranean, there is no reason to doubt what he says about having used a Columbus map. If any doubt is felt it concerns the precise nature and identity of the map used.

Dr. Kahle shows that for the north-western portion Piri evidently followed an older model than for the rest, and holds that its peculiarities are in striking accord with what we know of the ideas of Columbus. The portion embracing the Lesser Antilles, Virgin Islands, Porto Rico, and Trinidad, represents unmistakably the navigator's discoveries in this area, and most of the names applied are those actually given by him. When we come to the larger islands, Haiti and Cuba, there is no such obvious agreement. That which seems to do duty for the former is placed with its main axis running north and south. The names on it are indistinct, but Dr. Kahle thinks he can read San Domingo in one, and sees in the town shown on the right-hand coast the first settlement made on the island. The explanation suggested is that as Columbus imagined he had reached the Zipango of Polo, shown as running north and south on documents like Behaim's globe, he had been content to leave it thus on his map. To the west there is a continuous continental coast running also north and south, and this is identified with Cuba. No doubt Columbus did at one time regard this as part of Asia and as stretching southward a long way towards the Equator. Possibly here too he was influenced by older maps, and a similar misconception is displayed in the Cantino and Canerio maps, and in Waldseemüller's Carta Marina based on the latter. The identification with Cuba is supported by two of the place-names given, and also, in Kahle's view, by a certain resemblance to the form of the south coast of that island.

The rest of the north-west section is taken up with legendary islands such as commonly appeared in pre-Columbian maps, and these are thought to have been so shown on the original map in the navigator's hands during the first voyage. Apparently Kahle supposes that Columbus marked his own discoveries on this so far as space allowed, identifying others with lands marked on the old pattern of map without correcting their shape. He points out that all these imaginary islands are shown with the picture of a parrot attached, and suggests that Columbus drew the bird on these to distinguish them from his actual discoveries —surely not a very likely idea.

In dealing with these islands Kahle discusses the question of the supposed correspondence of Toscanelli, and its influence on Columbus. Here he speaks with no very certain voice. He dwells on the fact that Columbus gives no hint of any such correspondence; yet he sees agreements between Toscanelli's views and the Columbus map used by Piri, and allows that the search for Zipango during the first voyage does not accord with Vignaud's theory that the quest was merely that of new lands in the western ocean. On the other hand he shows that this view is consistent both with the statement had from the Spanish slave, and with Spanish official documents such as the Capitulation of April 1492.

While on the whole the argument is forcible and on some points fairly convincing, one cannot help seeing one or two weak points in it. There seems no very cogent reason for asserting the *whole* north-west portion to have been taken *en bloc* from the Columbus map. In one particular Kahle allows—as is, in fact, definitely stated by Piri—that use was made of the old "Mappamondos," namely for the representation of the legendary St. Brandan, with the whale taken at first, according to the story, for an island. Why may not the other legendary islands have been taken from such a source by Piri, rather than by Columbus? Even granted that all this portion was copied from the latter's map, is it likely that he would choose so rough and patch-work a drawing to send to Spain as an indication of his discoveries down to the end of the third voyage; for one of the arguments for identifying Piri's model with that sent home in 1498 is that, while showing Trinidad, it marks the opposite mainland as small islands which the points of the former sighted in 1498 were then taken to be? On the other hand there is no reason to doubt the truth of Piri's statement that he did make use of some map of Columbus, and his own map therefore deserves a place among the early documents bearing on the work of the navigator.

Besides reproducing the surviving part of Piri's map as a whole, the brochure gives an enlargement of the part ascribed to Columbus, and on this the names derived from him are added in Roman script, side by side with the Turkish. The names and legends are also provided with reference numbers, repeated in a list at the end of the text with references to the page on which each is discussed. Portions of other old maps are given for comparison, as well as a small modern map purporting to show the routes of Columbus on his first three voyages. By an apparent oversight, the tracks during the first two voyages are not shown completely, Cuba, for instance, being left untouched by them.

It is impossible here to say much about the rest of the map, which shows many points of interest: for example, careful drawings of Portuguese and other ships of the time. A striking feature is the continuous coast-line shown south of the Atlantic, possibly on the strength of Vespucci's voyage of 1501–2. It agrees closely with the similar feature in the Homem map of 1519, reproduced in the *Journal* for March 1931, and both must have been taken from an earlier Portuguese original—a confirmation, if such were needed, of the genuineness of the Homem map. An amusing derivation of the word "ocean" is supplied, this being given in the corrupted form "Ovasano," interpreted by Piri as "good egg."

EDWARD HEAWOOD

REVIEWS

EUROPE

THE BREEZY COAST (BERWICK TO JOHN O' GROATS). By A. A. THOMSON. *London: Herbert Jenkins* 1932. 8×5 *inches;* 288 *pages; illustrations and sketch-map.* 7*s* 6*d*

This book is a good example of the conversational type of guide-book for which there appears to be some demand. The author takes the coast road from Berwick to John o' Groats, and discourses lightly of history and people as he goes. From Berwick to Inverness Mr. Thomson follows the route taken by Johnson and Boswell, and one of the merits of the book is that there are frequent references to this famous journey. They give the narrative background and a certain dignity which it might otherwise be said to lack. But the author knows Scotland and its people well, and the book can be recommended to tourists who have neither the time nor the inclination for serious instruction; there are many pleasant descriptions of scenery. M. L.

OLD CHESHIRE FAMILIES AND THEIR SEATS. By LIONEL M. ANGUS-BUTTERWORTH. *Manchester: Sherratt and Hughes* 1932. $8\frac{1}{2}\times5\frac{1}{2}$ *inches;* 218+xviii *pages; illustrations.* 10*s* 6*d*

Mr. Angus-Butterworth has been at considerable pains to bring together and compress into the quite small space of 215 pages of large print, a great number of facts about the old families of Cheshire. In fact, he has done in the twentieth century for the Cheshire gentry and those interested in them what was done in the seventeenth by the historian of the county, Sir Peter Leycester, whose professed object was to save those who wished to consult Domesday Book trouble and expense.

Much of family history must necessarily read as a catalogue of Births, Deaths, and Marriages, but in this volume there are some good illustrations, and pleasant descriptions of Brereton, Bramhall, Lyme, and one or two other Halls. For a book of this size and price there are far too many misprints, of which the happiest makes *St.* Peter responsible for restorative work on Tabley Hall. C. W. M. B.

AN INDUSTRIAL SURVEY OF THE NORTH-EAST COAST AREA. Made for the Board of Trade by Armstrong College (University of Durham), Newcastle-upon-Tyne. *London: H.M. Stationery Office* 1932. $9\frac{1}{2}\times9$ *inches;* viii+506 *pages; diagrams and map.* 7*s* 6*d*

This is one of the series of studies of British Industrial Areas which now combine towards a national stocktaking of our resources for modern industrial developments. Nearly all of it has been produced by members of the staff of Armstrong College under the direction of Professor H. M. Hallsworth, who has himself done a very large share and to whom is mainly due the credit for a very thorough survey.

The volume consists of a General Report (pp. 1–55) and a series of studies on which it is based (Memoranda I to XV, pp. 56–505). These studies deal with the General Characteristics of the Area, the Natural Resources (a geological study of the mineral resources only, and therefore much narrower in scope than its title implies), agriculture, the several mining and manufacturing industries, and the Industrial Population, in great detail and with a wealth of statistical material.

The industries of North-East England have been almost summed up by the four words Coal, Iron, Ships, and Engineering. And because of its dependence on so small a range of closely interdependent basic industries it has suffered more than many other industrial areas from the recent depression. It has failed to

attract any considerable share of the new light industries of the twentieth century, largely because of its relative remoteness from the principal distributing centres. And since the relative, though not the absolute, importance of its industries seems likely to diminish, the North-East is not likely to regain its nineteenth-century prominence. The chief growth in it is that of the Heavy Chemical Industries round Billingham, in the south-eastern corner of County Durham, where there is an unusual combination of favourable conditions for those industries, including nearness to coal and limestone (both in varied qualities suited to different industrial needs), local deposits of salt, gypsum, and anhydrite, and a site by a navigable estuary on a large area of reclaimed marshland where expansion is not hampered by any previous occupation of the land. Imperial Chemical Industries already produce a considerable range of materials here; and here is the site of the proposed establishment for the production of oils from coal by hydrogenation. Teesmouth is the one section of the industrial North-East which has grown considerably since the War. Here, as everywhere else, progress is dependent on human intelligence and energy in making use of the natural resources; and the hopes of the Area rest, in Professor Hallsworth's words (p. 55), on "willingness and ability to appreciate new ideas, to adopt new methods, and to try out new enterprises."

C. B. F.

IN THE MOUNTAINS OF GREECE. By H. D. F. KITTO. *London: Methuen & Co.* 1933. $7\frac{1}{2} \times 5$ *inches;* x+150 *pages; illustrations and sketch-map.* 6*s*

GREEK CITIES. By PETER ANTHONY HUTTON. *London: J. M. Dent & Sons* 1932. $8 \times 5\frac{1}{2}$ *inches;* xii+26 *pages of text and* lxiv *pages of plates.* 10*s* 6*d*

Mr. Kitto's book is an unconventional record of a leisurely journey through Central Greece and the Peloponnesus. The author and his companion travelled on foot with a mule to carry the luggage. Their object was not to see classical Greece. They passed within 10 miles of Delphi but did not visit it. They desired to see mountains and people and enjoy themselves. A good deal of the travellers' enjoyment is communicated to the reader, and they met some odd and interesting characters—a German park-keeper, for instance, who tramped in one August week right through the Peloponnesus carrying a knapsack and an elaborate camera with legs and plates, and the foreman of a mine near Messene who was more interested in Oliver Cromwell than in Epaminondas. There are some good descriptions of Greek scenery, and the atmosphere, that of a scholar putting off his scholarship for a short time and devoting himself to whole-hearted enjoyment, is very refreshing. The book should take its place beside Dame Ethel Smyth's 'Three-legged Tour in Greece.'

The second book is a collection of really beautiful photographs of some of the lesser-known Greek cities. Mr. Hutton writes from first-hand experiences of Greek roads, Greek dogs, Greek maps, Greek tramlines, and Greek sanitation, and with real knowledge and insight upon the things that really matter, the charm of the scenery of Greece and the beauty of its monuments.

M. L.

THE STORIES OF BASEL, BERNE AND ZURICH. By M. D. HOTTINGER. (The Mediaeval Towns Series.) *London: J. M. Dent & Sons* 1933. 7×4 *inches;* xii+338 *pages; illustrations and plans.* 5*s* 6*d*

This is an able study of three towns which are oddly divergent in character, history, and appearance. Berne, a town of soldiers, had no commercial history, but Basel and Zurich grew up and developed on their trade. The history of the guilds of Zurich is to a large extent the history of the town. By the end of the thirteenth century the burghers were steadily drawing the power of the community into their hands, but the craftsmen rose against them and, headed by

Rudolph Brun, worked out a constitution which was to be the basis of government for five and a half centuries. Basel's fine patrician houses show how much it owed to its traffic, but its position as a frontier town involved it in disputes and difficulties of every kind. Unlike Berne and Zurich, Basel had a bishop to contend with, and before it was free of him there were troubles with the nobles. Its emergence as a trade-governed city was therefore somewhat delayed. That it was a fair and stately town is apparent from the reports of travellers from the fifteenth century onwards. To-day, at first sight, it is not a very beautiful town, but the inquiring traveller will find that it is full of beautiful things. The history of Berne is an exciting story. What with affrays and wars on its own account, and the business of extending its domains and fighting other people's battles, life there in mediaeval times must have been a perpetual commotion. Mrs. Hottinger weaves her way in and out among the tangled history of all three towns with skill and insight. Berne is still something of a show town, but travellers to Switzerland would be well advised to spare a little time for Basel and Zurich. With this instructive volume to guide them they will find much to interest and reward them.

Zurich has one episode in its history which should endear it to all Englishmen. Mrs. Hottinger's account of the life there of the Protestant refugees is among the best things in an excellent book. It is to be hoped that readers will turn to the Zurich Letters published nearly a century ago by the Parker Society. They can learn from Mrs. Hottinger's pages how much a friendly town can do to ease the lot of exiles, but the whole story deserves to be read in full. The plans are clear and well printed, and the illustrations well chosen. M. L.

ASIA

JAPAN UND DIE JAPANER. By KARL HAUSHOFER. Zweite Auflage. *Leipzig: B. G. Teubner* 1933. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii+240 *pages; illustrations and maps. M.*9.60 (*unbound M.*8)

The principle maintained by the school of which Dr. Haushofer is the founder and leader is essentially that even as geography has conditioned the political history of the world, so is it possible to deduce from geographical factors the future course of that history.

It is certainly possible to doubt whether the scientific historian will accept this principle of what may be termed a rigid geographical determinism. Nevertheless *Geopolitik* has this merit: it must of itself involve an exhaustive and methodic exposition of geographical and other data.

Considered in this light, Dr. Haushofer's heavily documented treatise on Japan and her people contains plenty of substantial information. Some of his deductions (*e.g.* in regard to climatic influences on national character) will hardly find unqualified acceptance; some of his statements—doubtless because of limitations of space—would seem to be somewhat arbitrary; his treatment of the relations between his own country and Japan bears the impress of national feeling. But, taken as a whole, the book is written in that spirit of scientific detachment at which its author aims, and merits the attention of the student of Far Eastern affairs. The description of the legal and civic status of the family and the individual in Japan (pp. 120 *et seq.*) is particularly interesting.

In the last eight pages of his book Dr. Haushofer sets forth the geographical and other forces at work in the complex situation in Eastern Asia. Whether or not history will implement his forecast of their consequences is an open question, but his detailed and careful analysis of that situation is in welcome contrast to the narrow and prejudiced views which are so frequently put before the public in this country and elsewhere. E. H. de B.

AFRICA

TRIBES OF THE NIGER DELTA. By P. AMAURY TALBOT. *London: The Sheldon Press* 1932. 9×5½ *inches;* xii+350 *pages; illustrations.* 18*s*

Mr. P. Amaury Talbot's anthropological studies in Southern Nigeria are well known and the present volume will be welcome as an additional source for students and others engaged in work in the coastal regions of the Bight of Benin. The territory covered in this monograph is known as the Degama Division and comprises an area of some 3670 square miles between the Niger and Santa Barbara Rivers on the west and the Imo and Andoni Rivers on the east, whilst the inland boundary is that of the Owerri and Onitsha Divisions. It stretches therefore from the coastal swamps to the forest. Owing however to the density of population little thick bush now remains save for a mile or two along the river banks and along the various settlement boundaries. The population consists principally of the Ibo and Ijaw tribes, the latter inhabiting the coastal zone among the swamps and marshes of the delta. Mr. Talbot writes chiefly of the Ijaw. His book is based on notes taken so long ago as 1914–16 and must be read in conjunction with other volumes from his pen, notably 'The Peoples of Southern Nigeria' (1926) and 'Some Nigerian Fertility Cults' (1927). But in spite of the delay in publishing his notes, the author is striking fresh ground which hitherto has scarcely even been noticed.

The worship of Ala, the Earth-Mother, is described most lucidly, and this is one of the clearest accounts yet given of a cult which is so important throughout West Africa. Together with ancestor-worship it is probably the foundation of all West African religious beliefs; but as the introduction of agriculture in the coastal zones is presumably of recent occurrence it is likely that the influence of the northern tribes through the presence of their members during the slave traffic affected its importance and brought about its predominance. Mr. Talbot shows many instances of how readily the Ijaw religious beliefs accept new teachings and how easily new ideas are adopted. His description of the ceremony called Kopinai during funeral customs is an instance of the acceptance and adoption of such, for Kopinai is a thinly disguised form of "company." But throughout the monograph there are frequent references to the influence of the Portuguese exploitation of the country with the inevitable influence on thought and practices.

Sections of the book treat of religion, water spirits, earth spirits, magic and witchcraft, pre-natal and birth ceremonies, marriage, divorce and widowhood, death and funeral customs, the soul, ghosts and other beliefs and superstitions. These are all fully and most interestingly recorded. Mr. Talbot often draws attention to discrepancies between his discoveries and those recorded by Mr. N. W. Thomas in his 'Report on the Ibo-speaking People,' and thus adds considerably to the value of his work for the student and for officers engaged in the administration of this area. Many unusual details are to be found. One would especially like to refer to the novel rules and restrictions which control behaviour during cooking and other housewifely duties.

Perhaps a single quotation will best illustrate Mr. Talbot's deep and sympathetic understanding of these people: "For most of us the very term 'juju' has grown to be almost synonymous with dark and dreadful crimes, hideous rites and the long-drawn-out agony of victims. Of the other side of the picture—of juju as a sanctuary for the oppressed, the forbidder of bloodshed, avenger of crime, no matter how craftily hidden, and the preacher of peace and goodwill—too little is known. Yet there is such a side." How true this is is gradually being learned, and most of the ugliness, as Mr. Talbot shows later, is due to the

accursed belief in witchcraft. Even the iconoclastic movement of 1916 to which the author makes frequent reference was marred by this belief, and elsewhere in West Africa similar gentleness beneath the roughness is being discovered.

The illustrations are excellent and the map serviceable. One might say that Mr. Talbot has made too frequent use of verbatim records of law-suits and complaints. To the general reader these are somewhat tiring, but the book is written rather for the student and to him the details given in such records are of immense value, particularly if the caution pronounced by Mr. Talbot is remembered, to beware of taking words from a native at their face value. "Usually, beneath native information there lurks a deeper depth, and infinite patience, time and care must be given if, at length, a little truth may be established." A. W. C.

LIGHT ON THE DARK CONTINENT. By CARVETH WELLS. *London: Jarrolds* 1933. 9½×6 *inches; 286 pages; illustrations and sketch-map.* 16*s*

One might review this book in a couple of lines by saying that it costs sixteen shillings (which is too much), has a frontispiece and two other illustrations depicting the author, and a foreword by Mr. Lowell Thomas in which he writes, "It's a relief and delight to come across a man . . . who even does a bit of wholesome debunking of the grandiose profession of exploration." But more is due to the author and intending reader. The first seven chapters have nothing to do with Africa, but deal with such varied subjects as the early settlement of Bermuda, the migration of lemmings, Lapps, and Swedish bathing customs. At chapter viii one turns hopefully to Africa, soon to be disappointed. Mr. Wells's method of shedding light on the dark continent is to set down a number of rather commonplace facts about its animals and inhabitants interlarded with stories heard during his travels. The last three chapters touch on the West Indies, the story of the *Bounty* mutineers and Malaya, and we close with an "appendix of strange and divers facts and figures" which seem to have little bearing on the subject of the book. There are some interesting photographs of high altitudes in East Africa, rather marred by the sub-titles. Some careless misprints could have been avoided; the third of the Ptolemies was Euergetes, not Evergetus (p. 154), and it is easy to quote Shakespeare correctly (p. 182). The author disarms criticism in his Preface, where he states that he claims no place for the book on the shelves of the highbrowed; one is chary of recommending even the lowbrowed to add it to their library list. W. B. K. S.

NORTH AMERICA

TIDEWATER MARYLAND. By PAUL WILSTACH. *Indianapolis: Bobbs-Merrill Company* 1931. 9½×6 *inches; 384 pages; illustrations and map.* $15.00

"Tidewater Maryland" can be described as the northern part of Chesapeake Bay. The greater part of Maryland is within easy reach of tidal water, as only seven of the State's twenty-three counties can be called "freshwater counties," and it is not surprising that this State saw the beginnings of the United States Navy. Mr. Wilstach deals with the history of this region from the time John Smith sailed up the Bay in the year 1607, and pays special attention to the social life of Maryland in the eighteenth century. Only brief reference is made to the history of the State in the nineteenth century. The book is written in a popular style, and is almost entirely historical. The parts of the book which may interest a geographer are those concerned with the foundation and development of Maryland's towns, Baltimore and the capital, Annapolis. According to Mr. Wilstach, Baltimore was first inhabited by white men in 1682 and was originally a walled

city. *The Star-Spangled Banner* was composed at Baltimore in 1814, and the town saw some of the earliest railway developments in America. The book contains a map of Maryland, some interesting illustrations of colonial houses, and an index. A bibliography is lacking and it is difficult to follow up some of the numerous quotations.

E. W. G.

CENTRAL AND SOUTH AMERICA

THE AMAZING AMAZON. By F. McDERMOTT. *London: Lincoln Williams* 1933. 9×5½ *inches;* 282 *pages; illustrations.* 15*s*

The author takes us up the mighty Amazon. We do not blaze a trail through unexplored jungle, but rather drift idly along multifarious waterways between walls of primeval forest. There are crowds of interesting things to look at and our guide interprets them in an attractive way. We peep into the riotous vegetation with its tall, straight tree-trunks, writhing, serpent-like creepers, pendulous masses of greedy parasites, and delightfully delicate-tinted leaves. We are introduced to the animal life of the jungle, so marvellously concealed in harmonizing tints and yet often so conspicuous through its ringing notes. The toothless ant-eater with its glutinous tongue; the sloth that climbs about like a slow-moving picture; the armadillo in his suit of medieval armour; the gigantic boa-constrictor that can swallow whole deer; the pheasant-like hoatzin with claws on its wings; the extravagantly beaked toucans and moth-like humming-birds; such are among the prodigal variety of life that we meet with in these forest-clad regions. We also get some glimpses of the human inhabitants, of men and women who go as naked as the day they were born, who fish with bows and arrows, shoot animals with blow-guns, and are adepts at the art of shrinking human heads. Thus the author has many things of interest to point out to us, and these, combined with the experiences of river-navigation, make a pleasing and instructive story.

R. W. G. H.

AUSTRALASIA AND PACIFIC

BACKWATERS OF THE SAVAGE SOUTH SEAS. By EVELYN CHEESMAN. *London: Jarrolds* 1933. 9½×6 *inches;* 286 *pages; illustrations.* 16*s*

Miss Evelyn Cheesman visited the New Hebrides, the Pacific Group with which this book is concerned, primarily as an entomologist; she spent two years in the group and has already published a popular account of the insect fauna she found there in her book, 'Hunting Insects in the South Seas'; for the scientific results of her expedition we may look to the appropriate journals. But while carrying out this work she met with so many strange and unexpected adventures and had such unusual opportunities of studying the natives, about whom very little has been recorded, that she found plenty of material for the present book, which deals mainly with her personal experiences in the island of Malekula. Until recently the Melanesian tribes who occupy the interior of the island had a bad name—thanks to the operations of blackbirders, recruiters, and the like: it was a case of "cet animal est très méchant; quand on l'attaque il se défend." They soon realized however that Miss Cheesman came amongst them with no ulterior motives, and she went where she would without molestation, penetrating districts unknown to the residents; when she became known a *tambu* was set upon her, signifying that her person was sacred, a fact which is a testimonial to her tact and patience in dealing with primitive people. Her book is an important addition to our knowledge of Malekula and its inhabitants, for the contacts she made

were more than cursory and she knew how to make the most of the chances that came to her. Her narrative is always readable, modest, and good-humoured, and she well displays her insight into native character in her description of the week she spent with Ringapat, the King of the Big Nambas tribe, a hospitable and likeable savage with enlightened views, who is doing his best to stamp out cannibalism amongst his people. O. R.

THE REAL SOUTH SEAS. By R. REYNELL BELLAMY. *London: John Long* 1933. $8\frac{3}{4} \times 5\frac{3}{4}$ *inches; 254 pages; illustrations and map.* 15*s*

Mr. Reynell Bellamy is a planter who has spent four years in the South Pacific; on his own admission he is no scientist, nor does he claim to have produced a complete epitome of the South Seas in a single volume. On the other hand he has written a very readable and succinct account of the various groups of the Pacific; his work is much more than a piece of mere bookmaking, for it is informed by personal knowledge and shrewd observation; and within his necessarily prescribed limits he is comprehensive. His book was certainly worth an index—it does not contain so much as a table of contents—and the maps, with the exception of that of New Caledonia, are on too small a scale and too littered with place-names to be of much convenience to the reader. He begins by a geographical description of the three main groups of islands: the Eastern Pacific groups, including Hawaii in the north, which constitute Polynesia; the westerly islands which make up what is known as Melanesia; and the thousands of islets, from the Pelews and the Carolines to the Gilberts, which go by the name of Micronesia. All these islands spring from one of three formations: there are those of volcanic origin, known as high islands, such as Tahiti and the Solomons; the coral (or low) islands and atolls, such as the Paumotus; and those, like New Guinea and New Caledonia, which are in reality out-flung portions of the continent of Australia. Mr. Bellamy deals with each of these groups, their discovery, history, flora, fauna, and inhabitants. Through his information he weaves a thread of personal reminiscence and anecdote, and one of his best chapters is that in which he describes the myriad forms of life that abound in the Pacific itself. O. R.

POLAR REGIONS

AU GROËNLAND, AVEC CHARCOT. By JEAN-LOUIS FAURE. [*Paris*]: *Flammarion* 1933. $7\frac{1}{2} \times 5$ *inches; 248 pages; illustrations and sketch-maps.* 12*fr*

M. Jean Charcot's character is well expressed in the name of his ship—*Pourquoi Pas?* When there was considerable doubt that France would participate in the polar year he threw the whole force of his influence and energy into the task of collecting the necessary money to take a wintering party to Scoresby Sound. M. Faure met Charcot by chance and was asked if he would like to sail with the *Pourquoi Pas?* "Volontiers," he said, and went. This book is a description of the voyage and of his reactions to the places he saw and the people he met. One cannot get a very comprehensive idea of Greenland life in less than two months, but M. Faure met Lauge Koch and Captain Ejnar Mikkelsen, and is definitely pro-Danish in his sentiments about the ownership of Greenland. M. Faure is stirred to a rich description of all he saw, the cliffs of the Faeroe Islands, the pack-ice, the Eskimos in their kayaks, and the northern lights. It was a pleasant voyage and successful in its object of landing a hut and supplies for the wintering party; but bad storms delayed them on their return, and a diary entry for September 2 reads, "Hélas! nous n'avons plus de vin." J. M. S.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

FLEUVES ET RIVIÈRES. By MAURICE PARDÉ. (Collection Armand Colin. No. 155. Section de Géographie.) *Paris* 1933. 7×4½ *inches;* 224 *pages; diagrams and sketch-maps.* 10.50 *fr*

This little volume is a very valuable addition to the Collection Armand Colin. It is written by an expert, and covers a wide range of subject-matter: Factors of the Régime of Rivers, Hydrological Calculations, Seasonal Variations, Floods and Low-water Periods, Transport of Solid Material, etc. It is written in a clear and interesting manner, and is illustrated by some useful figures and numerous tables.

The geographer should welcome it heartily. Text-books of Physical Geography seldom give much attention to the matters included in this volume. That in itself is not a criticism of such books because there is already so much included. But the teacher as well as the student will find M. Pardé's little work a very valuable companion volume to his text-book. There is a great deal of purely geographical material contained in it, and examples are taken from all over the world. An English translation would, in the reviewer's opinion, be well worth while.

Rivers and their work make up a large part in the teaching of Physical Geography, and here, in small compass, is a book dealing with what is often the less stressed, but no less geographical, aspect of the subject. There is a very close connection between the régime—in the broadest sense of that term—and the work of rivers as ordinarily developed in standard works of a more strictly geographical nature. The application of a more quantitative approach is desirable. How rapidly do changes of alluviation, of down-cutting, and so on, take place? "Cependant, les chroniques d'inondations, l'état actuel par rapport au plan d'eau des ponts très anciens et de leurs vestiges nous amènent à la conviction que, sauf en des secteurs limités, l'ensemble des cours d'eau européens coule à peu près aux mêmes niveaux qu' au moyen âge ou à l'époque romaine."

When, as now, the question of the origin of river terraces and raised beaches is so prominent, it is no bad thing to study rivers from the hydrological point of view as fully as possible. J. A. S.

CARTOGRAPHY

AN INTRODUCTION TO THE STUDY OF MAP PROJECTIONS. By J. A. STEERS. Third Edition. Revised and Enlarged. *London: University of London Press* 1933. 8×5½ *inches;* xxiv+228 *pages; diagrams and maps.* 8*s* 6*d*

A book on map projections without mathematics may be compared to a garden without flowers, but Mr. Steers's garden has plenty of well-kept lawns and tidy paths. As he states in the preface, his intention is to provide a guide to map projections for the non-mathematician, and he adheres to this faithfully throughout—except once or twice, as when, in dealing with the parabolic projection, he presumes a knowledge of the value of the sine of three times an angle, and of the area of a segment of a parabola. He is therefore rather limited in the projections that he considers and in the results that he demonstrates about them—Lambert's Orthomorphic and the Gauss Conformal have only the scantiest mention. He is however not so interested in investigating their various properties as in giving an account of the methods of constructing them as simply as possible. Starting with the zenithal projections, perspective and non-perspective, he passes on to the simple conic and polyconic, and the novice should not be upset here by rather frequent references to Bonne's projection, of which he probably has never heard, as that comes next. A good account of Mercator seems to be a little spoilt

at the end, as we are left with Edward Wright in 1599 adding up secants to find the distances of the parallels from the Equator, when as long ago as 1645 it was noticed that this leads to a logarithmic tangent.

The second part of the book deals with more difficult cases of the projections already mentioned, such as the transverse and oblique gnomonic and stereographic. Methods of construction are well explained, but an attempt to demonstrate the orthomorphism of the latter is rather unconvincing.

The chapters on Mollweide's and the parabolic projections are good, and all the way through there is an abundance of excellent figures and interesting outline maps. Those anxious to find out about the projections that appear in most atlases, and how to construct them, will find what they need here, presented in a readily understandable manner, though they must not expect to find how to make calculations of distances or angles from a map, a process requiring too much mathematics. R. K. M.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE MEDITERRANEAN IN THE ANCIENT WORLD. By J. HOLLAND ROSE. *Cambridge: University Press* 1933. 8×5 *inches;* xii+184 *pages; illustration and sketch-maps.* 8*s* 6*d*

The materials for a "naval history of the Mediterranean peoples" may be "scrappy and often untrustworthy," but that is no reason why such a history should be so. Frankly this is a disappointing book. The geography and ethnology of the opening chapter are sketchy: there are the usual "Etesian winds," the common mistake about the early use of the Corinthian isthmus (p. 12), complete neglect of the *imbat* winds, and of the Homeric evidence for trading Greeks (p. 11)—or does the mis-statement on p. 31 refer to *imbat?* So far from there being no word for "paddle" in Greek, the word itself is of Greek derivation, though in Greek ships the steering paddle was already lashed. "Mt. Temasa (or Tamasia) in Cyprus" is a complicated muddle. How did the Greek ἐπεξειρησία "increase the leverage of rowing without necessarily extending the beam of the vessel"? (p. 27). Odysseus's raft is no evidence for the "building of a primitive boat"; his tools were adequate, had he possessed shipwright's skill; he did not "weave" his sail (pp. 28–29); and he had commanded already a whole squadron of properly built transports. And who was Jack Deadeye? (pp. 31–32).

There is the usual loose talk in Chapter II about Phoenicians who "plied their tasks in mere cockle-shells," traded in "the corn of Gaul" and other far-fetched commodities, founded Monaco and Ortygia, and "offer tribute or blackmail to the Pharaohs for permission to trade." Is it true that the "Aegean microcosm" was "lacking the useful metals," or that the Cyrenaica barred the eastern extension of Carthaginian influence, or that "six cities have been built and sacked" at Hissarlik? And so on to the inevitable "merry Grecian coaster," and the notion that the Persian invasions were wirepulled from Tyre and Sidon (p. 55).

More detailed—indeed rather disproportionately—is the discussion of Artemisium and Salamis, but it contributes little but the Greek war-paean, "echoed from the cliffs all round," unconfirmed by the sketch-map for that part of Salamis bay which it shows. It is difficult to believe that the author followed his own advice as to study of the position; or that he had discovered Admiral Custance's "War at Sea." But the Peloponnesian War, with which that essay also deals, is not in Dr. Rose's plan of study.

While it is true in the main that "the West was the land of the sea," to regard the Ancient East as the "life of the desert, the steppe, and the torrid valleys of

the Tigris, Oxus, Indus, and Ganges" is to simplify it overmuch, though "trackless forests" are added to the scene on p. 101. The mirage of Corinthian gulf-geography reappears in an allusion to seafarers of "Corinth, Phocea, Corcyra, and the neighbouring coasts" (p. 77); and there is an odd phrase (p. 78) on a war fleet "tired by many days' rowing" around the Ionian Gulf.

The thesis of Chapter IV that "the Roman Empire depended quite as much on its fleets as on its roads" (p. 120) serves to bring together plenty of local information, but little constructive argument for the existence of such "fleets." The history of Roman Spain alone presents a series of difficulties which Dr. Rose hardly discusses. In Chapter V the same theme has to encounter the exploits of the pirates on the side of disorder, and of the Rhodians in defence of sea trade, and hardly does justice to either. In the long run the "durability of the Roman Empire" is ascribed to three main causes, into which Roman sea power is analysed as after all a secondary phenomenon, however potent in its economic consequences, as expounded in Chapter VI. In the discussion of the build and rig of Graeco-Roman shipping more use might be made of pictorial evidence to supplement the descriptions in *The Acts* and in Lucian, and also of Mediterranean shipping in post-classical times. Contrasts with ocean-going ships of later mediaeval times are misleading without the connecting links; and the superior seacraft of the Saracens is not even mentioned. J. L. M.

GENERAL

A VERY GALLANT GENTLEMAN. [L. E. G. Oates.] By L. C. Bernacchi. *London: Thornton Butterworth* 1933. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 240 *pages; illustrations and sketch-maps.* 8*s* 6*d*

To the reader without personal experience of polar exploration this book will doubtless appeal and a considerable sale may be expected for it. It is an exploitation of one of the most dramatic episodes of the quest for the South Pole, and it has as its theme a story that is worth writing—the personal biography of the central figure of perhaps the most arresting incident of the whole epic. Nevertheless, after reading it carefully, and in places extracting considerable enjoyment from it, the reviewer is left with the wish that the book had not been written in its present form.

The book falls between several stools. As a life of Captain Oates it fails necessarily because the author has not had access to essential sources of information. Presumably for the same reason, there are, as the reviewer is informed by those who should know, inaccuracies in the account of that portion of Captain Oates's life which was not subject to the revealing light that is brought to bear upon the members of the more spectacular polar ventures. As a further consequence of the inadequacy of the treatment of the earlier portion of Captain Oates's life, the account of the southern journey of Scott's Last Expedition has been expanded out of all proportion in order to make a book of reasonable length.

The attempt to make it more attractive to the general reader has caused the introduction of much extraneous matter which detracts from the value of the narrative either as a life of Captain Oates or as an account of the Scott disaster. As a general account of Antarctic nature and of a phase of Antarctic exploration now gone by it is again short of the ideal, in the opinion of the reviewer, chiefly on account of a certain extravagance of language and a tendency to exaggeration which suggests that Commander Bernacchi, whose claims as an authority on Antarctic matters cannot be questioned, since he has spent three winters on the Antarctic continent as a member of two notable expeditions and has since devoted

much time and thought to polar problems, has not given as much attention to the details of the narrative as he might have done. A notable instance is the statement that the average height of the Ross Barrier is 200 feet sheer from the sea (p. 80), a height that is altogether exceptional, the average height being under 100 feet. Emperor penguins "four feet high" must also be exceptional if the reviewer's own experience is a normal one, and there are other instances, not of direct exaggeration, but of an apparent association with the Scott Expedition of other Antarctic records that is unfortunately consequent upon the combination of general and special narrative that has been adopted throughout the book. The reviewer, who was with the expedition, feels certain that no Ross seals or sea leopards were killed, or even seen, in the voyage through the pack in 1911, and he has no recollection of a 4000-fathom sounding on that trip, though soundings of this order have been taken in Antarctic waters. A casual reference to metal sledge runners on the Beardmore Glacier (p. 161) is also clearly a memory of experiences on the Ferrar Glacier in 1902 or 1903.

One of the chief stumbling-blocks of the modern writer in recent polar history has been the need for description of the scientific activities of the expeditions. The present book is not too inadequate in this respect, but the geologist will find it hard to reconcile the query on p. 188, "Or did the grip of the frost king tighten on a green-clad Antarctica still too young to have developed animal life?" with the sentence on p. 229, "The present glacierization of Antarctica is particularly interesting, because its rocks reveal no earlier ice age, but, on the contrary, a warm and even subtropical climate in the past."

The most challenging statement in the book however is one on p. 53. It is there stated that Captain Scott replied, to a query of Captain Oates, "that he intended to take the *four* fittest men with him to the Pole" (the italics are Commander Bernacchi's). Apart from the fundamental error of preferring man to dog transport, which Scott shared with most British leaders—even McClintock, who had used dogs successfully, has recorded his personal opinion that for long journeys men are better than dogs—the main criticism that can be levelled at Scott is his sudden change from four to five men as his farthest south unit, when his whole sledging economy was based on the four-man party. This mistake would be a hundred times magnified had he actually intended from the first to use five men. The discrepancy is probably easily explained. Scott was, until a late stage in the expedition, not sure that he himself would be in the polar party. He told the reviewer as much before the Northern Party left Cape Evans. With this doubt in his mind he may quite likely have said that he intended that the four fittest men should go—not necessarily with him—to the Pole. The statement as made, and specially singled out for emphasis, by Commander Bernacchi ought not to pass without notice or challenge.

The statement that "nearly all the scientists were Cambridge men" on p. 52 is misleading; but the mistake is a natural one, since the work of the expedition was largely carried out at Cambridge after 1913, and the majority of those who began their career at other Universities were then generously adopted by Cambridge University. R. E. P.

THE LIFE OF MARY KINGSLEY. By STEPHEN GWYNN. *London: Macmillan & Co.* 1932. 9 × 5½ *inches;* viii + 272 *pages; portraits and map.* 12*s* 6*d*

The picture presented by Mr. Gwynn of Mary Kingsley, very largely from her own writings, is of a peculiarly attractive personality. She belongs to a type of woman much more common to-day of course than in her own generation, who, without being engaged in public affairs or administration, travelled widely and exercised an influence that was much more widely felt than that of the many

public servants who had their being in the countries she visited. Her ethnology, geography, and especially her politics were deeply concerned with human beings, whether they were West African negroes, traders, missionaries, or administrators. Her interests were how people lived and what they did in certain lands rather than what the lands were like where certain people lived. Thus when her feelings were aroused or her sense of justice violated her immediate reaction was to defend or fight the battles of all the many different sorts of people she met. Mary Kingsley's letters tell the story of her political evolution which played so great a part in interesting the public in this country in West Africa. They also depict a good-humoured and humorous woman who even in her most wrought-up moments could not resist smiling at herself. Her political influence reached its climax in the campaign over the Hut Tax controversy in Sierra Leone. She was beaten, but her generous personality found no room for bitterness towards her opponents. She nevertheless remained convinced that the imposition of the Hut Tax, however desirable or beneficial it might be, constituted a breach of faith with the West African natives who had by treaties voluntarily placed themselves under our protection. It is interesting to note that the reasons for her feeling about the injustice of the Hut Tax and her explanation of the violent opposition it aroused in West Africa were based on her knowledge of African customs and law, ignorance of which in this connection and over land tenure have been responsible for so many of our colonial troubles. Mary Kingsley saw, what the Colonial Office have only lately recognized by the appointment of Government anthropologists in various colonies, the necessity of "applied anthropology" in the art of colonial administration. F. R. R.

MODERN MOUNTAINEERING. By GEORGE D. ABRAHAM. *London: Methuen & Co.* 1933. 7½×5 *inches;* x+198 *pages; illustrations.* 7*s* 6*d*

The title of this book implies a wider range of subject-matter than its 169 pages can deal with. Chapters on "The Alps to-day," "Where to climb abroad," "Where to climb in Britain," as well as chapters on British, North-Welsh and Scotch mountaineering, with a final dissertation on up-to-date equipment, require more space than this volume affords. In a book of this size there would scarcely be room for a mere synopsis of so much subject-matter. However the author handles his task with a light touch, and if he produces a series of tentative sketches rather than a methodical treatise the book is none the less agreeable to read. Ninety pages are allowed to mountaineering abroad and the remainder of the volume is given up to the British hills which the author knows so well.

There is a sprinkling of errors in the text, and the accuracy of some of the statements may well be questioned. It is scarcely correct, for example, to say that the best guides prefer to be paid according to the tariff and not on a daily rate. On p. 24 the claim that the cornices on the Lyskamm no longer exist is one that mountaineers would be ill advised to rely upon. It would also be interesting to know the author's grounds for believing that the Fontaine chimney on the Dent du Requin is often ascended direct, and on p. 161 it is surely too much to assume that if that great mountaineer, the late Mr. O. G. Jones, had been leading on the fatal day of the accident, the disaster would never have happened. It would be easy too to point out better rock climbers than the guide who is here cited as Mr. Jones's ideal. Another guide referred to on several pages as Peter Knubel is Joseph Knubel.

Among the names mis-spelt are: Montanvert (or Montenvers), Col des Grands Montets, Aiguille de Blaitière, Col des Nantillons, Grands Mulets, Péteret, Predigstuhl, Val de Bagnes, Saas Fee, Dreieckhorn, and Adang. The book is well illustrated with excellent photographs. C. F. M.

THE MONTHLY RECORD

RAINFALL IN THE BRITISH ISLES, 1820–1930

Discussing rainfall over the British Isles in each of the eleven decades 1820 to 1929 in the *Quarterly Journal of the Royal Meteorological Society* for July 1933, Dr. John Glasspoole produces maps expressing the rainfall of the several decades as a percentage of the average for the standard period 1881 to 1915. Sufficient information was available for all parts of the British Isles in the case of the six most recent decades, but for 1860–69 and 1880–89 it was only possible to define the rainfall over England, Wales, and Ireland, while for the three earliest decades the distribution is given for England alone—on the basis in the case of 1820–29 of no more than fourteen well distributed stations.

The decadal maps enable the mean annual amount of a short rainfall record covering any of the decades to be corrected to give the average for the standard period, and it is to be hoped that the general trend of the lines on the maps whose production shows considerable ingenuity are correct. But it is pointed out in the discussion of Dr. Glasspoole's paper, apart altogether from the vexed question of the propriety of using any period like 1881–1915 as a standard normal, that the validity of the decadal maps, not to say the possibility of drawing them at all from so few stations, depends on the extent to which we may rely upon a fairly definite ratio subsisting between the variations of local rainfall from year to year and the local averages. If, for example, the record from a place with an average rainfall of 25 inches goes up to 30 inches in a wet year, can we rely on a place not far away in the hills whose average is 50 inches getting 60 inches in that same wet year? Dr. Glasspoole in reply expresses confidence in the stability of this ratio, adding that the distribution shown on the percentage maps is independent of configuration. Nevertheless it is difficult to believe that the ratio does not sometimes seriously break down, and to the extent that it may the maps must be unreliable. It is quite certain that in the wilder parts of Great Britain a good deal happens in the shape of weather that never comes to light, and great caution should be exercised before covering the map of the country with lines of this character.

THE RÉGIME OF THE TIBER

Thanks to the systematic observations inaugurated within recent years by the Italian Hydrographic Service, more exact information has been supplied on the régime of the Tiber (among other Italian rivers) than has been hitherto available. Some of the results have been published in Italy by Professor Pietro Frosini, but as they are contained in technical journals not easily accessible, geographers will welcome the masterly summary given in the *Revue de Géographie Alpine* (Tome XXI, 1933, Fasc. 2) by M. Pardé, whose similar studies of other rivers have been referred to more than once in the *Journal*. The régime of the Tiber presents some unusual features, which give it a special interest.

For a river draining a mountainous region the general inclination of its bed is but moderate, its main headstream coming from only 1500 m. at most, though many of the ranges flanking both it and its tributaries reach much greater heights. A factor of prime importance is the nature of the soil in different parts of the basin, for while the main valley, with the whole western part of the basin, lies on impermeable formations, the eastern side is formed of extremely porous rocks into which the rainfall sinks rapidly. The precipitation over the basin varies, as in all mountain regions, according to the special orographical features, but the differences are not so great as in some French and Swiss basins. The total is also less

than in the case of many Alpine rivers. Most rain falls in autumn, with a secondary maximum in early spring. There are great differences in the discharge of the several feeders in relation to the extent of country drained, and these are much greater than is accounted for by differences of rainfall. The coefficient of run-off is extraordinarily high for tributaries like the Nera, reaching as much as 80 per cent., the reason being that the water sinks into the ground so rapidly that it is largely removed from the effect of evaporation. The paper enters into full details on the seasonal variations in the flow in the separate sections of the basin, discussing especially the causes and nature of the floods for which the Tiber has long had a reputation. M. Pardé shows that this is in reality little deserved. The Tiber does not show the typical characteristics of Mediterranean rivers—extremes of high and low water, and a generally poor supply. The mean discharge is fairly good, and while its floods fall far short of those of many other rivers, its low stages are by no means serious, thanks to the good offices of the Nera and other affluents which drain the limestone regions of the east.

HISTORICAL CHANGES IN THE MOUTH OF THE EMS

A valuable study of the changes to which the mouth of a river has been subject during historic times is contributed to the *Annalen der Hydrographie*, Heft 3, 1933, by Friedrich Windberg, who reconstructs the story of the Lower Ems in a convincing way by a judicious correlation of existing physical conditions with historical and geological evidence. The Lower Ems is a lowland stream marked by many windings, with the usual tendency for gradual exaggeration of the curves until the course is once more straightened out by breaking through of the water. In the Ems of to-day below Emden the result of such a process can be clearly seen. The old course, which alone bears the name Ems, swings from side to side four times before reaching the sea, while in each case there are duplications of the waterway by more recently formed channels to which the name *Gat* is applied, and which owing to their more direct course tend to be increasingly used by shipping. The force which has been responsible for the new cuts has not been the flow of the river, or the ebb which takes the same direction, but the flood water, as is proved by the way in which the cuts can be seen to have started from the west or seaward side. This is substantiated by historical documents. The earliest chart which can be called in is that of Waghenaer (1584), which clearly shows the uppermost of the new cuts, but no trace of the others. Sixty years later a careful survey of the channels of the river-mouth was made by Martin Faber by direction of the Emden authorities, and as it is confirmed by an almost contemporary, but independent, report, it may be taken as correct. It, too, shows that the one cut only existed in 1642. The process can be explained by the recent sinking of this area which is vouched for by the freshwater formations shown by borings to exist below the recent marine sediments, the old coast-line having run outside the line of the East Frisian islands, and the tide then failing to penetrate into the area under discussion.

The above refers to the present main mouth of the river—the West Ems, and the history of the East Ems is somewhat different, though closely bound up with the other. In Roman times, and down to about A.D. 1300, the two were separated by the large island of Bant, the eastern branch debouching near the present island of Norderney. A document of 1398 proves that the original large island had already been broken up into small fragments, no doubt owing to the sinking of the area; this created a new East Ems (west of its old position), which for a time was used by shipping almost as much as the main western branch. With the new cuts formed in the latter, more and more of the river water took a western direction, with the result that the East Ems is now almost disused.

HIMALAYAN JOURNAL, VOLUME V

The new volume of the *Himalayan Journal* is magnificently representative, dealing with the ranges extending from Chitral to the Irrawaddy. An account of the exploration of the sources of this latter river is given by Mr. Kingdon Ward. His aim was to collect the fauna and flora of the district and to continue to trace the orientation of the great ice-sheet that once covered so much of this country from the Tsangpo to the Yangtse and beyond. Another great journey is that described by Dr. Hellmut de Terra, leader of the Yale North-Indian Expedition. His account here only deals with the country south-east of Leh, the region of the Pangong and Moriri lakes, between which lie the upper reaches of the Indus, where it flows westward from Tibet. Dr. de Terra's concluding pages give a brief summary of the geographical, geological, biological, zoological, and botanical work performed.

There are two important contributions by mountaineers: the leader of the 1933 Everest Expedition writes on the problem of how to reach the foot of that formidable mountain, Nanda Devi, hitherto unapproachable, and Herr Merkl writes about his recent attack upon Nanga Parbat. A curious discovery in connection with this attempt is that the method of bivouacking in artificially made ice-caves which had proved so useful to the Bavarians on Kangchenjunga was of no assistance on Nanga Parbat owing to the different climate in this part of the Himalaya. A further article records the Tibetan journey of Messrs. Williamson and Ludlow. From Gartok they visited Tsaparang, now a comparatively dead city. No traces of the Jesuit Mission or church survive, and the cross seen by Mr. Mackworth Young twenty years ago has disappeared.

The editor contributes a paper on the latest vagaries of the dangerous Chong Kumdan Glacier on the Shyok in Ladakh. Fortunately the inundations caused no loss of life in 1932. Incidentally Professor Mason criticizes current views on the ebb and flow of glaciers. Among the "Notes" are references to the well-known brilliant achievements of the Everest Flight Expedition, also the less well-known but equally remarkable routine flights of the Royal Air Force in the neighbourhood of Nanga Parbat. The height reached by the R.A.F. machines is not mentioned but the distance traversed, from Risalpur to Gilgit, varied according to the route chosen between 205 and 286 miles.

At the end of the volume the translation of Sir Filippo De Filippi's work of 528 pages, giving an account of the explorations by his expedition in the north-west in 1913 and 1914, is reviewed by the editor, who remarks: "there is not a shadow of doubt that a better organized or more comprehensive scientific expedition has never explored the Indian borderland." 'Kamet Conquered,' the record of the successful expedition by Mr. F. S. Smythe's party, is also reviewed. Smythe's campaign on Kamet deserves to be accepted as a model for all ambitious Himalayan mountaineers. Finally the editor of the *Alpine Journal* reviews Herr Bauer's narrative of the second great Bavarian attack on Kangchenjunga. Astonishing gallantry was again shown in this protracted battle against the mountain; the attack proper lasted for nine and a half weeks and only ended at 26,000 feet when prohibitively dangerous snow was encountered.

Professor Mason is to be congratulated on an admirable volume of his *Journal*, which is now printed at the Oxford University Press, and looks very attractive in its new Baskerville type. C. F. M.

CLIMATE OF DEATH VALLEY, CALIFORNIA

Death Valley, a typical desert region in the south-east of California, extending in a north–south direction between high mountains for about 100 miles and averaging about 10 miles wide, is notorious for having furnished one of the

highest authentic air temperatures recorded on the Earth's surface. In 1911 the U.S. Weather Bureau established a climatological station at Greenland Ranch, an irrigated tract on the eastern side of the valley 178 feet below sea-level, and the twenty-years' record now available is discussed by Mr. E. E. Ekland in the *Monthly Weather Review* for February 1933. The extreme reading of 134° F. on 10 July 1913, which, until a temperature of 136° F. was recorded at Azizia, Tripolitania, on 13 September 1922, was the world's highest known air temperature, is but an incident of intensely hot summer conditions. Thus maximum temperatures over 120° occur on the average four times in June, ten times in July, and five times in August, and in 1917 were recorded on 43 consecutive days, there being also 113 consecutive days over 100°. Temperatures over 100° have occurred in all but four months of the year, November to February, and no month has failed to reach 85°. Minimum temperatures as high as 100° are not unknown in the hot season, but the nights in winter are decidedly cold. The absolute minimum of 15° F. (seventeen degrees of frost) which occurred on 8 January 1913, the same year as the heat record, affords a telling commentary on the known fact that the highest maximum temperatures do not occur near the Equator.

Most of the deaths from misadventure which have given this valley its name appear to be due to thirst. The average annual rainfall at Greenland Ranch, which is not considered to be either the driest or hottest part of the valley, is 1·4 inches, but in 1929 no rain at all was measured. Rainfalls exceeding an inch in twenty-four hours have occurred four times in twenty years, but the violent thunderstorms which breed in the mountains on either side and produce torrents in the cañons which discharge into Death Valley are rare in the valley itself. Although the relative humidity sometimes falls below 5 per cent. in summer there are periods when a high percentage of saturation prevails, and clouds are frequent. Contrary to general belief, numerous sources of water, such as springs, rivers, and marshes, usually highly mineralized, exist in or near Death Valley.

SIERRA NEVADA MORPHOLOGY

Under the title "The Little 'Lost Valley' of Shepherd's Crest" Mr. François E. Matthes describes a very exceptional piece of mountain sculpture in the High Sierra of California, one among a large number of remnants of an ancient landscape which chiefly takes the form of tabular summits of slightly convex contour [*Sierra Club Bull.*, February 1933]. The feature in question, a V-shaped valley about three-quarters of a mile long and half a mile wide at an altitude of 12,000 feet, is on the top of the mountain known as Shepherd's Crest whose sharp pinnacles stand out prominently near Virginia Cañon above the McCabe Lakes. Flanked by steep precipices, the mountain is joined to the main divide of the Sierra Nevada by a long attenuated arête resulting from glacial erosion which has enlarged the deep cañons on both sides to capacious cirques. In spite of the heavily glaciated character of the environment the mountain-top valley exhibits none of the characteristic signs of glaciation—of erosion by moving masses of rock-laden ice. Instead the slopes are covered with a mantle of frost-riven fragments characteristic of high mountain slopes which have borne no active glaciers but only inert drifts or fields of snow. For this process the author long ago proposed the term "nivation" in contradistinction to "glaciation."

Corroborative evidence of non-glaciation is furnished by the V-shape cross-section of the valley, since even a moderate glaciation at any period would have made it U-shape and destroyed the central stream channel. The proof that this summit valley escaped glaciation during the Pleistocene is held to strengthen the indications that the surrounding tabular summits of normal outline likewise escaped it. The explanation offered is that the high summits of the Sierra Nevada

not only rise well above the altitude of heaviest snowfall, but are all, Shepherd's Crest included, inclined towards the south and south-west—that is, towards the sun and prevailing winds. The latter blow great quantities of snow over the crests, leaving the broad sunny slopes bare during part of the summer and causing heavy accumulations to supply the glaciers which fill the cañons on the north and north-east flanks. This effect is likely to have been still greater during the Ice Age when the snow clouds were lower and the winds more violent than to-day. Shepherd's Crest and the other summits which appear to form so many relics of a once continuous landscape are believed to date back to the early Eocene, some fifty million years ago, and to owe their preservation with comparatively little change largely to their having escaped glaciation.

ST. LAWRENCE DEEP WATERWAY

Reference was made to the plans of the St. Lawrence Deep Waterway in the *Journal* for October 1925. The treaty controlling its construction has been signed by the United States and Canada, but has yet to be ratified by both legislatures. Sir Alexander Gibb, in the *Royal Engineers Journal* for June, describes the plan briefly and considers at more length objections raised against it, and its probable effects upon the economic position of Canada. Two general points are emphasized: the necessity to the Canadian farmer of cheap transport at all costs, and the dominant part played in North American economics by the Great Lakes system. At present, for the area west of Central Saskatchewan, *i.e.* one-third of Canada, Vancouver is functioning as an effective and economic grain-shipping port for Europe. The Great Lakes are now of approximately equal carrying capacity, and improvements being carried out at Sault Ste. Marie and at St. Clair will provide a draught of 24 feet. The capacity of the Welland Ship Canal, formally opened in 1932, is considerably in excess of these. The large lake boats cannot however reach Montreal, and it is the purpose of the St. Lawrence Deep Waterway to secure this. The three full-sized canals required on the St. Lawrence, and the deepening of other sections are estimated to cost £35 million.

The scheme is favoured by the Canadian and Middle West farmers, and the ports on the Great Lakes: also by the New England states, who will obtain cheap hydro-electric power from the proposed works. The writer states that though the income from the sale of power will considerably lighten navigation costs, it will not, as was often predicted, pay for the entire construction. The opposition to the scheme comes chiefly from the railways, alarmed at the prospect of subsidized competition, from Quebec, and largely from Montreal. The people of Quebec are adverse to the selling of power to the United States, as an alienation of natural resources: Montreal is alarmed for the future of her entrepôt trade, and almost of her existence as a port. The effect of a possible rival canal from Buffalo *via* Albany to the Hudson River, entirely in United States territory, is feared. As for her entrepôt trade, the writer points out that ocean-going vessels will be at a disadvantage with the lake steamers, with regard to size, rapidity of loading, and ability to run to minimum time schedules: in fact, with good management, he believes that Montreal may enjoy an increased traffic. The construction of the Deep Waterway will limit the formation of "frazil" ice, which will reduce damage caused by flooding, and may keep the St. Lawrence open longer to navigation. One engineering problem to be met is the continued fall of the St. Lawrence level for the past fifty years.

THE COUNTRY BETWEEN THE RIO BRANCO AND SIERRA PARIMA

The portion of the Amazon basin lying west of the Rio Branco, and between the Rio Negro and Rio Uraricoera, is little known apart from these river courses,

which have been surveyed by Dr. Hamilton Rice. In the *Geographical Review* for July Mr. Desmond Holdridge describes an expedition he made last year in an attempt to penetrate this area to study primitive Indian life. The first river ascended was the Rio Catrimany, a large right-bank tributary of the Branco, first explored by Lobo d'Almada in 1787. After a month's journey, the party reached his farthest point, and continued for another week, until supplies were almost exhausted. It was established that, contrary to previous opinion, the Catrimany in its upper reaches maintains a north-to-south course, and does not come from the west. Mr. Holdridge estimates its source at 30 miles beyond the point he reached. On the journey neighbouring hills were climbed where possible, and bearings taken. Peaks were seen extending from W.N.W. to N.N.W.; the Sierra Itakuari, some 80 miles above the confluence with the Branco, was visible; also the unbroken wall of the Sierra Parima, with a low range between. Progress westward by the Shiriana, a tributary of the Catrimany, failed, owing to the flooded forest.

An ascent was then made of the Rio Demeni, a left-bank tributary of the Negro. Through the help of Shiriana Indians contact was established with some Maiká Indians, approximately 150 miles upstream. From an adjacent hill much of the topography seen from the Rio Catrimany could be recognized. It is probable that the source of the Demeni is close to that of the Parima. Later a tributary, the Aracá, coming from the north-west, was ascended, and further details about the Sierra Parima were obtained. Mr. Holdridge shows that it must extend farther to the south-east than has been assumed, and that opinions on the hydrography of this area require to be modified. A preliminary sketch-map, based on his bearings and photographs, and on previous surveys, accompanies the paper.

OIL PRODUCTION OF THE WORLD

The geographical conditions affecting the production of oil are concisely analysed by Dr. Alfred Thoran in a monograph published by B. G. Teubner (Leipzig 1932). After a brief introduction, each of the oil-producing countries of the world is dealt with separately in respect of the position of the oilfields and the conditions of soil, climate, and labour supply under which they are worked. This study brings out the strong position held by the two American continents, and especially the United States, where the fields are in general well placed with respect to communications and world-markets, and enjoy a climate which does not hinder production or severely tax the health of the workers. According to the figures given for 1930, 80·4 per cent. of the world's supply is produced by the two Americas, the United States alone supplying 64 per cent. and Venezuela 10 per cent. These countries are followed at a considerable distance by Russia, Persia, Romania, and Mexico. The feature of the past decade has been the great increase in the output of all the South American fields.

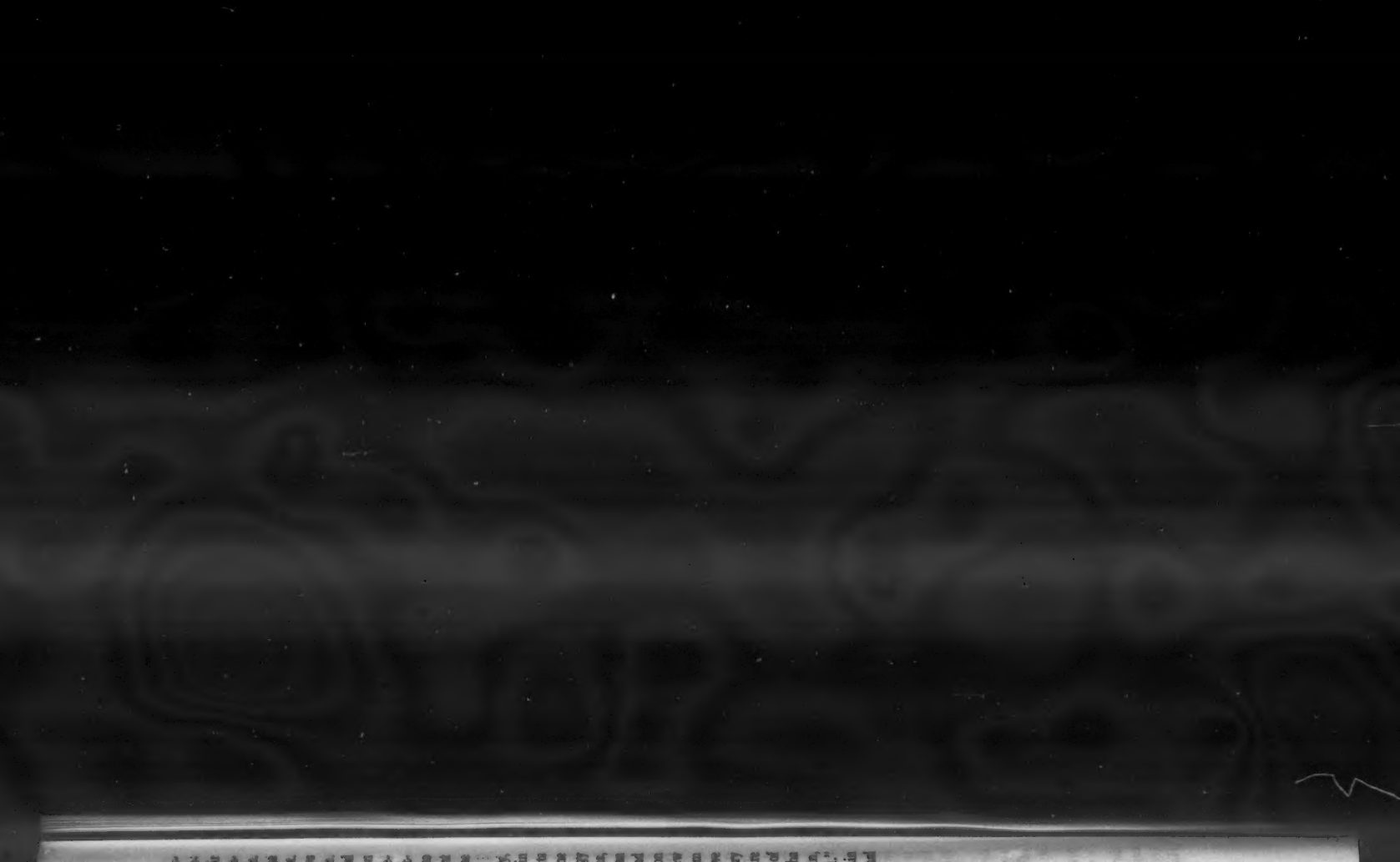
The monograph is illustrated by numerous diagrammatic maps showing the destination of oil exports. The statistics, which in general are brought down to 1930, will be useful to students. A commendable feature is that, unlike some other writers on this subject, Dr. Thoran has kept international politics out of his study.

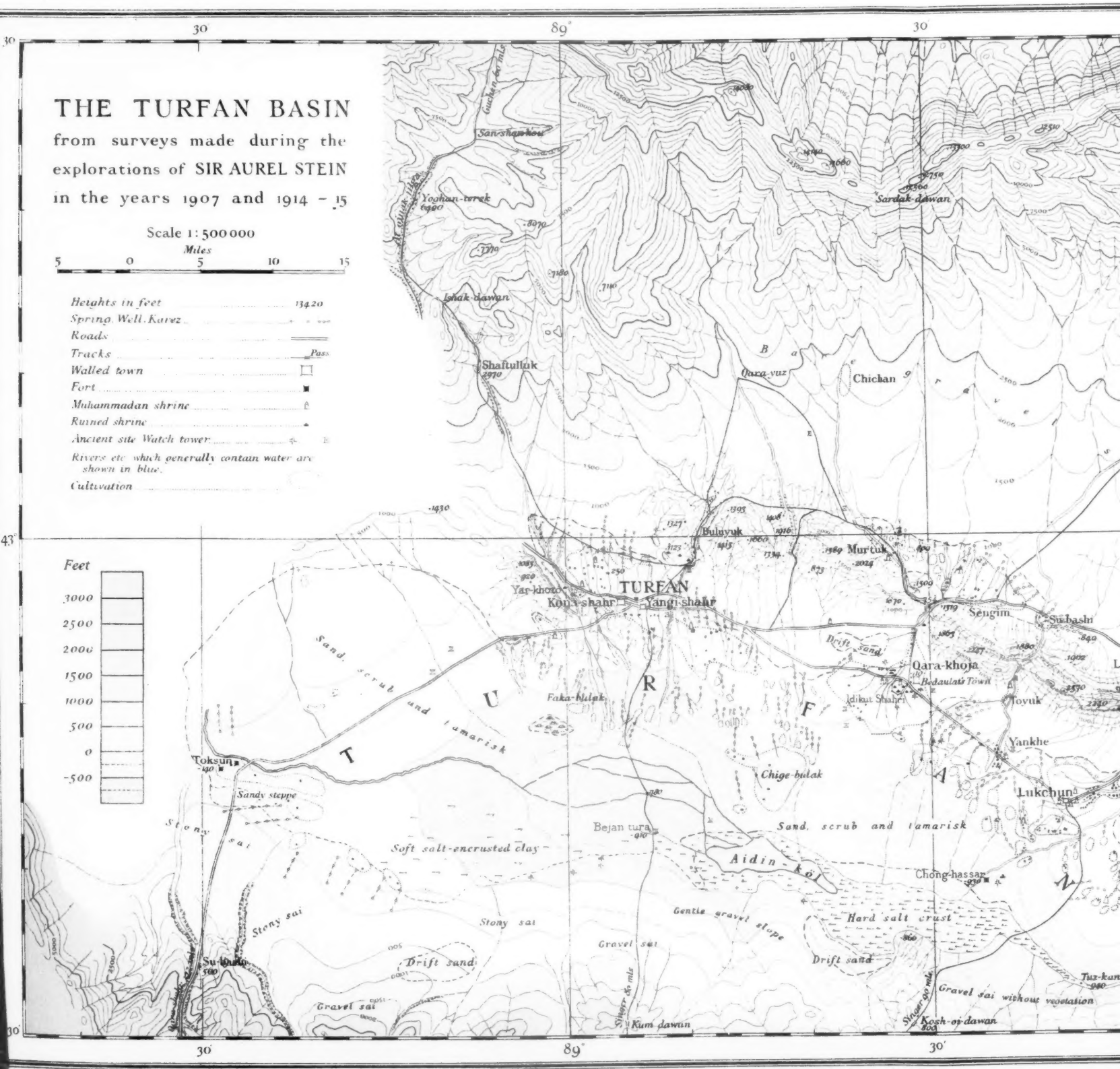
NEW GERMAN GEOGRAPHICAL PUBLICATIONS

Two new German series have commenced publication recently. Both are devoted largely to the geographical aspects of settlement in relation to environment. The Geographical Institute of Berlin University is issuing *Berliner Geographische Arbeiten*, of which two parts have been received. The first, by W. Hartke, deals with changes in the human geography of North-East France

brought about by the war devastation and reconstruction. His general conclusion is that all recent developments in agriculture, economic life, and distribution of population were foreshadowed in pre-war days, though their quickening may be attributed in most cases to the war. Areas of heavy depopulation are markedly associated with those areas in which fighting was most severe. Urbanized areas show great increases, largely owing to the universal drift to the towns—in contrast to the rural districts, some of which showed a 30–40 per cent. decrease between 1911 and 1926. The structure of the population also shows changes, as the influx from the rest of France and from abroad has been large. In the second part, H. Winz attempts to draw a complete picture of the cultural geography of the Upper Inn valley from personal observation and research in archives. Most of his space is given to the development of settlement from prehistoric times, leading up to a consideration of the present distribution. Outstanding features, which react upon each other, are the reversion of tillage to meadow-land, and depopulation. In some districts one-quarter of the land went out of cultivation between 1860 and 1928, owing, in some instances, to the advent of alternative sources of livelihood.

The second series, published by the Geographical Institute of Kiel University, begins with a monograph by H. Wenzel on the basin of Ak Shehr. This area, in the south-west of the high interior steppe lands of Anatolia, depends for its prosperity upon the streams and springs fed by the north-eastern slopes of the Sultan Dagh range. The author therefore pays special attention to the hydrology and irrigation system. The district of Ak Shehr, according to the 1927 census, has a population density above the average for inner Anatolia, slightly more than 20 per square km. Actually, about 62 per cent. is concentrated in the west, around the town. There are three elements: "Turks" in a wide sense, the old population whose methods and villages have persisted unchanged for centuries; a few settled nomads on the slopes; and, mostly in the north-east, immigrants from Russia since 1865 and more lately from the Balkans. They appear to have numbered about 2400 in 1927, of whom about 900 gave Greece as their country of birth. These immigrants have had a very favourable effect upon agriculture in introducing new methods and technical skill—especially in the making of artesian wells. In the second monograph of the series, Charlotte von Trotha narrates the development of rural settlements along the coast near Köslin, Pomerania. Several types of village forms are found here, including the "round." The writer attacks the view that these are solely of Slav origin, seeking to explain their form in relation to their geographical environment. One of the original documents reproduced is a portion of a large-scale map dated 1588.





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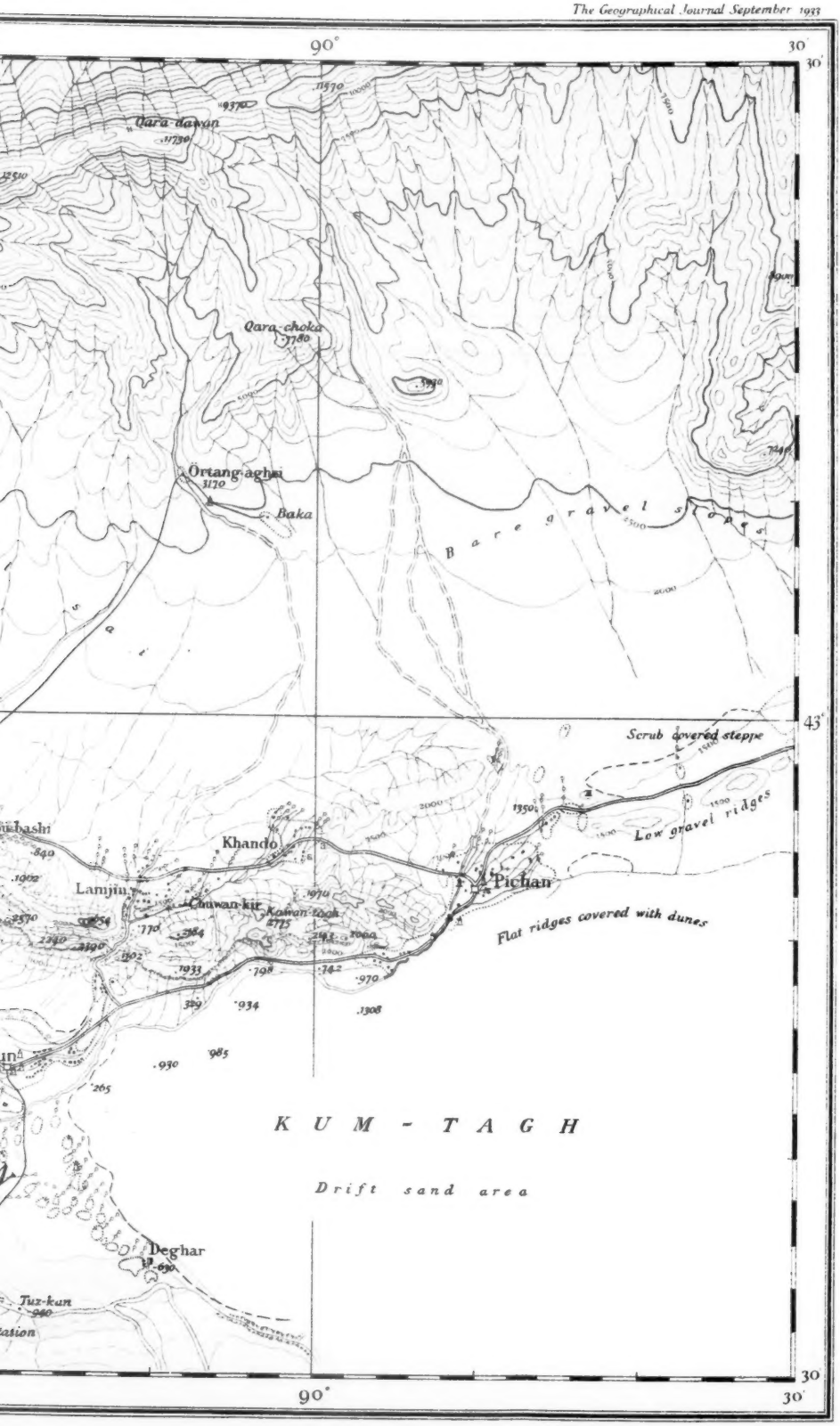

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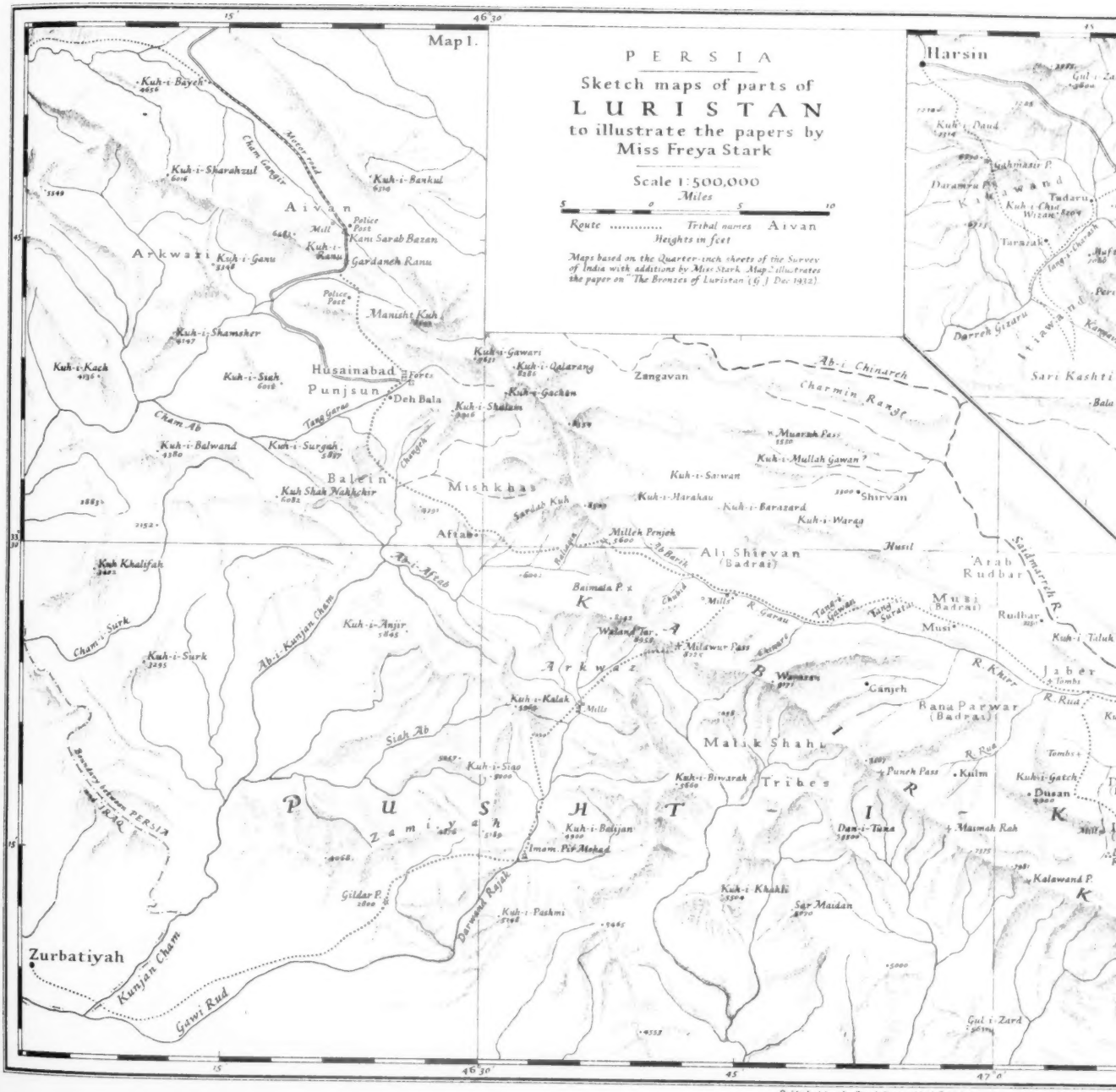

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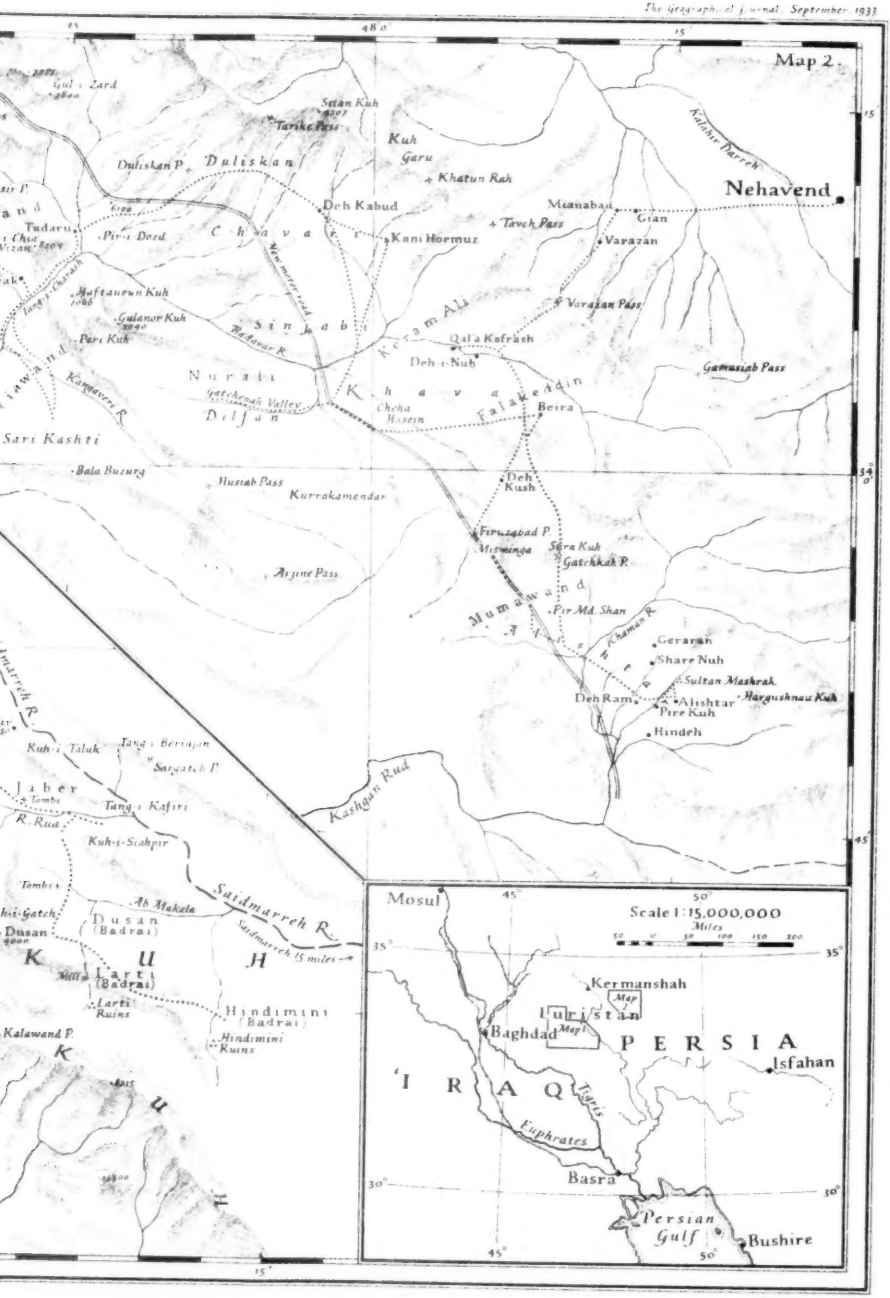

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